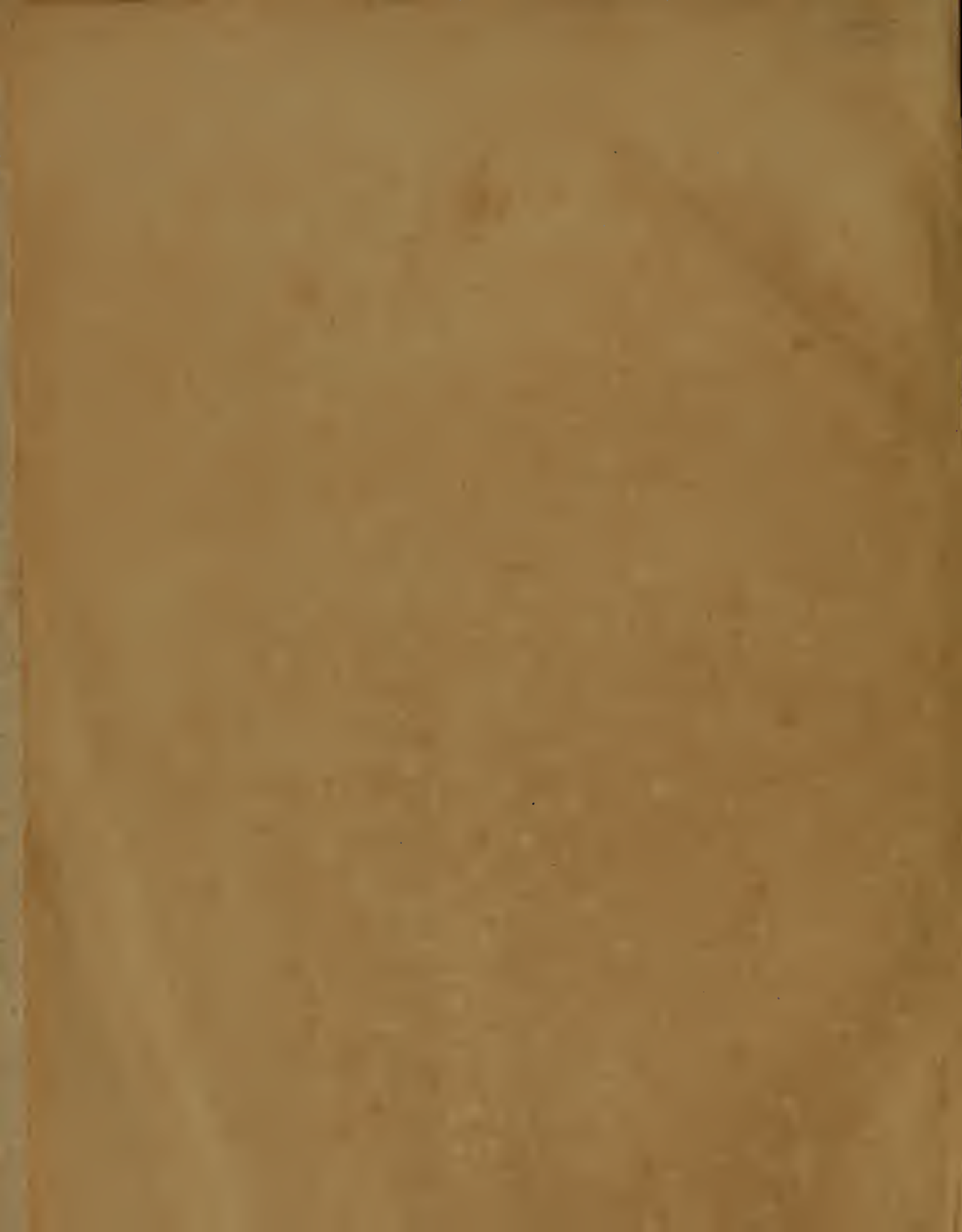


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Capt. Symonds - 37th Regt

CLASS. BOOK

FOR

THE SCHOOL OF MUSKETRY

HYTHE.

PREPARED FOR THE USE OF OFFICERS.

BY

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HYTHE:

W. S. PAINE, STATIONER, POST OFFICE, HIGH STREET.

1861.

INTRODUCTION.

THE School of Musketry was founded in 1853, by the then Commander-in-Chief, the late Viscount Hardinge, as a normal school of instruction in Musketry.

It has for its especial object the formation of officers and non-commissioned officers to act as instructors in the several battalions throughout the Army.

In the book of "Regulations for conducting the Musketry Instruction of the Army," promulgated by order of His Royal Highness the Commander-in-Chief, it is ordered at page 33, and paragraph 35, that, "The Commanding Officer is to assemble the officers "of the battalion at least once in each half-year, and to cause the non-commissioned "officers and men to be assembled occasionally by squads or companies, at other times "than when the annual course is proceeding, when the officer-instructor, having previously "explained the theoretical principles detailed in the foregoing lessons, will be at liberty "to advance deeper into the subject, developing to a degree proportionate to the rank "and intelligence of his auditors, the whole history of small arms, from the first invention "of gunpowder, and the successive steps by which the rifle-musket has attained its present "efficiency; in order that the officers and soldiers, by acquiring a thorough knowledge "of the subject theoretically, may take a greater interest in the practical part of this "most important branch of their duty."

The following Lectures have been prepared for the use of officers qualifying at the School of Musketry for the positions of Instructors in their respective Regiments. They are not to be considered as complete treatises or histories, but merely as "aids" to instruction, which can be expanded by the Instructor in *viva voce* Lectures, and if bound with an alternate ruled blank leaf, they may be corrected and enlarged when desirable, to suit the various improvements in arms, &c., introduced from time to time.

INTRODUCTION.

These Lectures are a mere compilation, extracted from a vast amount of interesting and valuable matter, systematically arranged. The names of the various authors upon whom wholesale plunder has been committed are mentioned in the course of the work, and the compiler hopes this general confession may secure their pardon.

The Theory of Gunnery has been very slightly touched upon: it cannot be pursued by any persons unless well grounded in Mathematics, and the short time passed by officers at Hythe wholly precludes so abstruse a study. Our School is decidedly a practical institution; to acquire an art or skill is our object, and we only broach the subject of Theory to soldiers, so far as to enable them to understand the reasons for all those rules which have to be attended to in practice.

E. C. WILFORD,

COLONEL.

HYTHE, *January*, 1861.

C O N T E N T S .



	PAGE.
✓ History of Gunpowder	1
✓ Manufacture of Gunpowder	7
✓ Foreign Gunpowder <i>foreign</i>	20
✓ Explosive force of Gunpowder	29
✓ Experiments with Gunpowder	36
Magazines	23
Lightning Conductors	24
Greek Fire	4
✓ Ancient Engines of War... ..	39
On Artillery	62
Portable Fire Arms	73
The Rifle	86
The Bayonet	83
Accoutrements	84
Breech-loaders	92
On Rifling	95
On Rifle Projectiles	101
Theoretical Principles	110
Gravity	113
Atmosphere	115
Form of Bodies	119
Causes of Deviation	121
Windage	121
Rotation	122
On Eccentric Projectiles	124

ERRATA.

- Page 6, para. 5, line 6, for "*have before stated*" read "*shall state*."
Page 20, last line but one, for "*altogether*" read "*all together*"
Page 25, para. 3, line 5, for "*descriptive*" read "*disruptive*."
Page 30, para. 3, line 9, for "*expansive*" read "*expansion*."
Page 31, para. 3, line 1, for "*art*" read "*act*."
Page 32, para. 7, line 9, for "*considerable*" read "*considerably*."
Page 32, para. 6, line 10, for "*Robert*" read "*Piobert*."
Page 35, para. 3, line 1, for "*sulphurate of Potassa*" read "*sulphide of Potassa*."
Page 36, para. 4, lines 1 and 2, for "*which is a mortar*" read "*the chamber being*."
Page 40, last line but 3, for "*Polyrectes*" read "*Polyorctes*."
Page 41, para. 4, line 10, for "*IX*" read "*XII*."
Page 53, para. 2, line 9, for "*incredible*" read "*incredibly*."
Page 66, para. 6, line 2, after "*has*" insert "*a*"
Page 78, para. 5, line 3, for "*753in.*" read "*·753in.*"
Page 78, para. 5, line 3, for "*16*" read "*14½*."
Page 79, line 4, for "*600*" read "*6,000*."
Page 84, para. 2, line 1, for "*Latinat*" read "*Catinat*."
Page 84, para. 2, line 1, for "*masquitairy*" read "*mousquetaires*."
Page 86, para. 10, line 2, for "*Carabins ragecs*," read "*Carabines rayées*."
Page 86, para. 12, line 1, for "*Subalterns*" read "*Non-Commissioned Officers*."
Page 89, line 3, for "*range*" read "*raye*."
Page 89, line 3, for "*ball culot*" read "*balle à culot*."
Page 91, para. 5, last line, for " $\frac{7}{100}$ " read " $\frac{1}{100}$ "
Page 93, para. 8, line 1, for "*wounds*" read "*rounds*."
Page 98, para. 1, lines 6 and 7, for "*possible. For,*" read "*possible; for*"
Page 103, para. 3, line 7, for "*proportionary*" read "*proportionate*."
Page 103, para. 5, line 4, for "*reserved*" read "*reversed*."
Page 105, para. 6, line 3, for "*horn-wood*" read "*horn, wood*,"
Page 112, para. 1, line 8, after "*direction*," insert "*b*."
Page 114, para. 2, line 7, for "*16—48—80*" read "*16+48+80*."
Page 115, para. 2, line 2, for "*sign*" read "*tangent*."
Page 115, para. 2, for "*plate 21, fig. 3,*" read "*plate 22, fig. 3*."
Page 119, para. 3, line 1, after "*moving*," insert "*in*."
Plate 21, fig. 5, should be lettered as fig. 4, plate 22.

HISTORY OF GUNPOWDER.

The History of Gunpowder may well form a prelude to that of Fire Arms, as the existence of the latter is wholly dependent on the discovery of the former. Of all the discoveries which have been made, there is, perhaps, none which has produced more important consequences to mankind than the discovery of Gunpowder, as by introducing fire-arms, and a new method of fortifying, attacking, and defending Towns, it wrought a complete change in the whole art of war.

The invention of Gunpowder is completely involved in obscurity, and this very fact is one great proof of its antiquity. Knock observes that the invention of Gunpowder comprises several discoveries, which it is necessary to distinguish from each other.

Knock's
opinion.

1st.—The discovery of Nitre, the principal ingredient, and the cause of its detonation.

Order of
discovery.

2nd.—The mixture of nitre with sulphur and charcoal, which, properly speaking, form gunpowder.

3rd.—The application of powder to fire-works.

4th.—Its employment as a propelling agent for throwing stones, bullets, &c.

5th.—Its employment in springing mines and destroying fortifications.

All these discoveries belong to different periods.

Mr. Dutens carried the antiquity of gunpowder very high; and refers to the accounts given by Virgil, and others, of Salmonens' attempt to imitate thunder, presuming from hence that he used a composition of the nature of Gunpowder.

Mr. Dutens's
account.

It has been said that it was used in China as early as the year A.D. 85, and that the knowledge of it was conveyed to us from the Arabs, on the return of the Crusaders to Europe.

Known in
China, A.D.
85.

The Brahmas and Indians, whose practice is recorded by Philostratus, in his life of Appolonius Tyanæus, written about 1600 years ago. "These truly wise men," says he, "dwell between the rivers Hyphasis and Ganges; their country Alexander never entered, their cities he never could have taken, for they come not out to the field to fight those who attack them, but they overthrow their enemies with tempests and thunderbolts, shot from their walls."

Known in
India, A.D.
250.

This is a most striking illustration of the antiquity of Gunpowder, for if some such composition be not implied in the foregoing quotation, it must remain for ever perfectly unintelligible.

Saltpetre, which is the principal ingredient of Gunpowder, is found in its natural state in the East, and from this it seems highly probable they were acquainted with the composition of Gunpowder before the Europeans.

Powder at
siege of Mec-
ca, A.D. 690.

The Arabs are said to have employed Gunpowder at the siege of Mecca, A.D. 690.

Oldest book
on gunpowder
A.D. 900.

There is a manuscript book still extant, entitled *Liber Ignium*, written by Marcus Græcus, who lived about the end of the eighth century, and the composition there prescribed is 6lbs. saltpetre, 2lbs. charcoal, 1lb. sulphur, to be well powdered and mixed in a stone mortar.

Work on gun-
powder in Es-
curial Collec-
tion A.D. 1249

There is in the Escorial Collection a treatise on Gunpowder, written in 1249.

Roger Bacon
on powder,
A.D. 1267.

Our countryman, Roger Bacon, who was born 1214, and published works at Oxford 1267, expressly mentions the ingredients of Gunpowder, not as any new discovery, but as a well known composition, used for recreation. He describes it as producing a noise like thunder, and flashes like lightning, but more terrible than those produced by nature; and adds that it might be applied to the destruction of an army or a city. Bacon, in his treatise "*De Secretis Operibus*," says that from saltpetre, sulphur, and wood coals, we are able to make a fire that shall burn at any distance we please.

Tradition of
Schwartz,
A.D. 1320.

The common tradition of Bartholdus Schwartz having invented Gunpowder and Artillery, about 1320, is without the slightest foundation, but he might possibly have suggested the simplest application of it to warlike purposes, in consequence of some accidental explosion while mixing the ingredients in a mortar. Indeed, the name, as well as the form of the old species of artillery, which was employed to throw large bullets at an elevation, strongly corroborate this conjecture; but Schwartz cannot lay any claim to originality of invention.

Mortar.

Powder made
in the reign
of Richard II.
1378.

Gunpowder was made in England in the fourteenth century, as Richard II. commissioned Sir Thomas Norwich to buy, in London, or in any other place, certain quantities of "sulphur, saltpetre, and charcoal," for making Gunpowder.

Tartaglia on
Powder,
A.D. 1500.

Tartaglia, at the commencement of the sixteenth century, sets down twenty-three different compositions, made use of at different times, the first of which, being the most ancient, consists of equal parts of nitre, sulphur, and charcoal.

Ancient gun-
powder weak.

Gunpowder, for some time after the invention of artillery, was of a composition much weaker than what we now use, or than that ancient one mentioned by Marcus Græcus; but this, it is presumed, was owing to the weakness of their first pieces, rather than to the ignorance of a better mixture.

Graining.

The change of the proportion of the materials composing it was not the only improvement it received. The invention of graining it is doubtless a considerable advantage to it; for powder, at first, was always in the form of fine meal, such as it was reduced to by grinding the materials together. It is doubtful whether the first graining of powder was intended to increase its strength, or only to render it more convenient for the filling into small charges, and the charging of small arms, to which alone it was applied for many years, whilst meal-powder was still made use of in cannon. But at last the additional strength which the grained powder was found to

acquire from the free passage of the fire between the grains, occasioned the meal-powder to be entirely laid aside.

That powder was first used in meal, and continued in its old form for cannon long after the invention of graining it for small arms, are facts not to be contested. Tartaglia expressly asserts that in his time cannon-powder was in meal, and the musket-powder grained. And our countryman, William Bourne, in his "Art of Shooting in great Ordnance," published forty years after Tartaglia, tells us, in chap. I, that serpentine powder, (which he opposes to corn, or grained-powder) should be as fine as sand, and as soft as flour: and in his third chapter he says that two pounds of corn-powder will go as far as three pounds of serpentine-powder.

Tartaglia wrote, 1537.
William Bourne, 1577.

We learn from Tartaglia, that the cannon-powder was made of four parts saltpetre, one part sulphur, and one part charcoal; and the musket-powder of forty-eight parts saltpetre, seven parts sulphur, and eight parts charcoal; or of eighteen parts saltpetre, two parts sulphur, and three parts charcoal. These compositions for musket powder are very near the present standard; the first having, in one hundred pounds of powder, about one pound of saltpetre more than is at present allowed, and the second three pounds more.

Tartaglia on the proportions.

Nye, in his treatise on fireworks, gives the proportions of the ingredients, and the dates when they are used, thus in 1380 equal parts of each were employed. This would be about as efficient as a common squib of the present time. In 1410, three parts saltpetre, two sulphur, and two charcoal. In 1520, for the best powder, four parts saltpetre, one sulphur, and one charcoal, and afterwards, five saltpetre, one sulphur, and one charcoal.

Nye's treatise on the proportions.

In fact, Gunpowder was merely those substances combined, with little or no purification. It was not at first corned or grained, as at present, but remained in its mealed state, and was called "serpentine powder," in several accounts of stores in the time of Edward VI., and Elizabeth.

Early gunpowder mere mixture.

Soon after this two kinds of powder were used for the same gun, one in its mealed state (for priming only) as being more readily ignited by the match, the other, corned or grained, for the charge in the gun barrel.

Two kinds.

The application of powder to mines, and to the destruction of fortifications, does not appear to have been in practice before the end of the fifteenth century.

Powder first used to explode mines in 15th century.

Camden, in his life of Queen Elizabeth, says that she was the first who procured Gunpowder to be made in England, that she might not pray and pay for it also to her neighbours; but it has been stated that it was previously made in the reign of Richard II.

Elizabeth had powder made, 1558 to 1603.

Sir Henry Manwayring, in his Seaman's Dictionary, presented to the Duke of Buckingham, in the time of Charles 1st, under the word powder, tells us, "There are two kinds of powder, the one serpentine-powder, which powder is dust (as it were) without corning. The other is "corn-powder;" though he informs us the serpentine-powder was not used at sea. Indeed, when that book was written, it is believed powder was usually corned, for the foreign writers on artillery had long before recommended its general use.

Charles I. from A.D. 1625 to 1649.

Causes which
checked the
progress of
Fire-Arms.

Fire-Arms
supposed to
extinguish
bravery, and
to be contrary
to humanity.

Fire-Arms
expensive and
powder diffi-
cult to procure

Rockets in
India.

Various circumstances tended to check the progress of fire-arms, and the improvement of artillery, for a long period after the invention of gunpowder. Custom made most people prefer the ancient engines of war. The construction of artillery was very awkward and imperfect; and the bad quality and manufacture of gunpowder, so that it could produce but little effect; and there was a general aversion to the newly invented arms, as calculated to extinguish military bravery, and as being contrary to humanity; but above all, the knights (whose science was rendered completely useless by the introduction of fire-arms) opposed, with all their might, this invention, to which may be added the great cost and difficulty of procuring gunpowder.

It is known that iron rockets have been used in India as military weapons, time out of mind. (See plate 4, fig. 3.)

GREEK FIRE.

Discovered
by Callinicus.
A.D., 617.

Known in
China, 917.

Wild fire
from the
Saracens.

Wild fire in
the Holy
Wars.

Geoffrey de
Vinesauf's
account.

Father
Daniel's
account.

Used at the
siege of
Dieppe.

Greek fire and
gunpowder,
both used at
the siege of
Ypres, 1383.

The Greek Fire has been highly extolled for its wonderful effects, but it owed much of its effect to the terrors and imagination of the beholders. It is said by the Oriental Greeks, to have been discovered by Callinicus, an architect of Heliopolis or Balbeck, in the reign of the Emperor Constantine Poganatus, who, it is said, forbade the art of making it to be communicated to foreigners, but it was at length known, and in common use, among the nations confederated with the Byzantines.

It is also said to have been known in China in 917, being 300 years after Constantine Pogonatus, under the name of "The oil of the cruelfire," and was carried thither by the Kitan Tartars, who had it from the King of Ou.

It was thrown by machines, by the hand, and by cross bows, fastened to the heads of arrows. The Crusaders obtained a knowledge of a sort of wild fire from the Saracens, which could only be extinguished by dust or vinegar. It was composed of the gum of resinous trees, reduced to powder with sulphur, to which was added naphtha, and other bitumens, and probably nitre.

It is much spoken of in all the Holy Wars, as being frequently employed by the Saracens against the Christians. Procopius, in his history of the Goths, calls it Media's oil, considering it an infernal composition prepared by that sorceress. Geoffrey de Vinesauf, who accompanied Richard I. to the Crusades, says that it could not be extinguished by water, but that sand thrown upon it abated its virulence, and vinegar poured upon it put it out. Father Daniel says this wild fire was not only used in sieges, but even in battles, and that Philip Augustus, King of France, having found a quantity of it ready prepared at Acre, brought it with him to France, and used it at the siege of Dieppe, for burning the English vessels in that harbour.

The Greek fire was used long after the invention of firearms; when the Bishop of Norwich besieged Ypres, 1383, the garrison is said by Walsingham to have defended itself so well, with stones, arrows, lances, and certain engines called guns,

that they obliged the English to raise the siege with such precipitation, that they left behind them their great guns, which were of inestimable value.

Greek fire was probably a more recent invention than Gunpowder.

It is ascertained that Gunpowder was employed by the Arabs as an agent for throwing bolts and stones, about the commencement of the fourteenth century, and that the Moors first availed themselves of its advantages in their wars with the Spaniards. From Spain, the use of Gunpowder and Artillery gradually extended itself to France, and thence over the other States of Europe.

Powder used
by Arabs,
14th century.

Some idea of the importance of Gunpowder may be formed by the estimate of the enormous quantity employed in sieges, and warfare generally.

At the siege of Ciudad Rodrigo, January, 1812, 74,978lbs. were consumed in 30½ hours; at Badajos, March, 1812, 228,830lbs. in 104 hours, and this from the great guns only.

Quantity used
in sieges.

At the two sieges of San Sebastian, 502,110lbs. At Zaragoza, the French exploded 45,000lbs. in the mines, and threw 16,000 shells.

San Sebastian
and Zaragoza.

During the siege of Sebastopol, extending over a period of eleven months, the enormous quantity of 2,775,360lbs., or 1,239 tons of gunpowder, were expended by ourselves alone; 9,076 tons of shot and shell having been launched by us on that memorable occasion, from 476 pieces of heavy ordnance; of which only 11 actually burst, though 269 were rendered unserviceable.

Sebastopol.

Some of our private manufactories make from 8 to 10,000 barrels of powder a year in time of peace, and from 10 to 14,000 during war.

Quantity
made.

The quantity of powder received and proved from Faversham, at the Royal Magazines, and from the several powder makers contracting with Government, amounted, during the several years from 1776 to 1782 inclusive, to 244,349 barrels of 100lbs. each, being equal, on an average, to 3,490,700lbs. annually. The quantity of powder in store in Great Britain, Guernsey, Jersey, and the Isle of Man, in 1783, was about 80,000 barrels.

Quantity
proved by
Government.

Quantity in
store in 1783.

Sir George Staunton observes, that gunpowder in India and China seems coeval with the most distant historic events, and that the Chinese have at all times applied it to useful purposes, as the blasting of rocks, and also in the preparation of fireworks, in which they greatly excel other nations.

Gunpowder
used for works
of peace.

In blasting the Woodhead tunnel, in the county of Chester, not less than three thousand five hundred barrels of gunpowder, weighing about one hundred and sixty tons, were used in its formation. The average number of men employed was about a thousand; and during the six years the works were in progress, twenty-six men were killed. There were about 400 minor accidents, many of them attended with loss of limb, and the sum total of the casualties, in proportion to the men employed, was greater, according to Mr. Edwin Chadwick, than was suffered by the British army in the battles of Talavera, Salamanca, Vittoria, and Waterloo.

Powder used
at Woodhead
tunnel.

Powder used
on S. Eastern
Railway.

In the formation of the South-Eastern Railway, the blasts of the cliffs between Dover and Folkestone have astonished even scientific men. On one occasion 18,500 pounds of gunpowder were ignited by galvanic action at the same instant, which severed from the Round-down cliff, the height of which is 375 feet above the level of the sea, more than 1,000,000 tons of chalk. The fallen mass extended 1200 feet into the ocean, and covered a space of 18 acres. By another statement, the quantity of earth moved by the explosion was 400,000 cubic yards, and was a saving to the Company of £7,000.

No. of men
employed at
Waltham
Abbey.
Quantity
made.

There are 134 men employed in the Government works at Waltham Abbey in the manufacture of gunpowder, who make about 9,000 barrels a year. The premises are near two miles long, consisting of detached mills, &c., on a small stream, which runs through the whole length of the premises and communicates with the Thames, whereby there is water-carriage to the Government Powder Magazines at Purfleet. The barges conveying powder are not allowed to anchor in the river off London during the night. Where two buildings are adjacent, there are frequently heavy buttresses of masonry between them, and lightning conductors are placed in great numbers.

Saving to
Government.

There is a great saving, amounting to upwards of £300,000, in the cost of powder, when compared to the price paid to the merchants in seven years of the war from 1809 to 1815, from the Government having Waltham Abbey, Faversham, and Ballincollig.

Improved
Quality.

At Waltham Abbey, in a very few years after it was constructed, the powder was so improved, that the charge of powder to the weight of shot was reduced from one-half to one-third; therefore two barrels were used instead of three—an advantage in stowing on board ship as well as in the field.

Made by
Contract.

A great part of the powder for H. M. Government has at present to be supplied by merchants. The contracts are made out sometimes for them to supply their own saltpetre, and at others for the Government to furnish it pure, at the rate of 77·5 lbs. per barrel of 100 lbs., they finding the other materials and manufacture, a corresponding reduction in price being made: as, however, it has to come up in nearly all respects to the sample, the requirements of which we have before stated, certain proofs have to be undergone before being received for the different services.

NOTE.—The foregoing is mainly compiled from *Robins's New Principles of Gunnery*, by Hutton; *Engines of War*, by Wilkinson; and *Projectile Weapons of War*, by J. Scofield, M.B.

ON THE MANUFACTURE OF GUNPOWDER.

Gunpowder is an explosive propellant agent; a mechanical combination and intimate mixture of saltpetre, charcoal, and sulphur, in certain fixed proportions, the result of successive experiments.

To be effective, Gunpowder should,

1st.—Preserve itself in a good state, whether in magazine or in carriage.

2nd.—Leave as little residue as possible after ignition.

3rd.—Should combine a certain quickness of combustion with great explosive force.

Composition
of powder.

Ought to keep
without
deterioration.
Leave no
residue.
Combine
quickness and
power.

SALTPETRE, OR NITRE.

The principal ingredient in Gunpowder is an abundant production of Nature, and is a combination of nitric acid with the vegetable alkali. It is never found pure, being always contaminated with other salts and earthy matter. It is principally found in the East Indies, Ceylon, and South America, and is sometimes produced from decayed animal and vegetable matter. It is totally unfit for Gunpowder until it has been refined; for, being combined with muriates of soda, lime, magnesia, and other salts, which absorb moisture, the close contact of the ingredients would be deranged by their presence, the strength of the powder weakened, and the power of resisting the action of the atmosphere greatly lessened. As for the efflorescent salts it may contain, they are noxious only inasmuch as, possessing no particular useful property, they interpose their atoms between the more combustible ingredients, and impede the rapidity of deflagration.

Nitre.

Where found

Unfit in natu-
ral state.

There are two methods of refining saltpetre at Waltham Abbey:—1st, the Old Method, of re-crystallizing three times; and 2nd, the New Method, which has only just been adopted, both of which we shall here briefly describe.

Two methods
of refining.

OLD METHOD.

About 35 cwt. of the rough saltpetre, as it is termed, viz., as it is imported in its impure state, is put into a copper capable of holding 500 gallons, with 270 gallons of water, in the proportion of about 1½lbs. of nitre to 1lb. of water, (which proportion varies with the quality of the saltpetre). This is allowed to boil, and the

Old method.

impurities are skimmed off as they appear on the surface. Cold water is occasionally thrown in to precipitate portions of the chloride, which otherwise would remain on the top by the action of boiling. After being allowed to boil from three and a half to four hours, the furnace doors are thrown open, when the chlorides and salts fall to the bottom. In about two hours, a copper pump is lowered into the liquor, which is pumped out into a wooden trough, having four or five brass cocks, under which are suspended canvas filtering bags in the shape of a V. The solution is then filtered, and run off into pans, containing about 36 gallons, and allowed to remain for twenty-four hours, to crystallize, when they are set up on edge, to drain off the liquor which remains uncrystallized, and which is called mother liquor. The saltpetre thus obtained is called once-refined, and undergoes the same process twice again, the only difference being that there is a greater proportion to the water each time, viz. $1\frac{3}{4}$ lb. to 1 lb. of water the second time, and 2 lb. to 1 lb. of water the third time: moreover, the third time, a small quantity of ground charcoal is put into the solution, and it passes through double filters, which brings it to a very fine pure white colour when melted. The mother water which remains in the pans after each crystallization is conveyed away by gutters to cisterns under the building; it is then evaporated in iron pots to one quarter of its original bulk, filtered, and allowed to crystallize. The saltpetre obtained from the first mother water is considered one stage inferior to grough; that from the second, equal to grough; that from the treble-refined, equal to once-refined saltpetre. The water left from every stage is treated in the same way, so that actually nothing is lost of the pure material. Saltpetre treble-refined by this process is perfectly pure, and fit for the manufacture of Gunpowder; and in order to free it from moisture, as well as for the convenience of storage and transport, it is melted in iron pots holding about 4 cwt., by raising it to a temperature of 600° Farenheit, and cast into gun-metal circular moulds holding about 38 lbs. each. It must be observed that it requires about two hours to bring the saltpetre into a liquid state, and that, after this, the furnace doors are thrown open, to lower the heat to the proper temperature for casting into the moulds. When the cakes are cold, they are packed away in barrels containing 1 cwt., 1 qr. each, and put into store. Care must be taken, in melting the saltpetre, not to raise it to too high a temperature, as this would reduce the quantity of oxygen, and form nitrite of potash, which would render it unfit as an ingredient in the composition of Gunpowder.

Saltpetre
fuzes at 600°

A neutral
salt.

Saltpetre is a neutral salt, the constituents of which are 46.55 potash, and 53.45 nitric acid; the latter consisting of two volumes nitrogen and five of oxygen. It is white, and of a fresh, sharp, and slightly bitter taste. It crystallizes in six-sided prisms. Exposed to the air, it remains permanent unless impure, or that the atmosphere is very moist.

NEW METHOD.

New method.

Forty cwt. of the grough saltpetre is put into a copper with 270 gallons of water, and treated in precisely the same way as we have before described for the first

refining; it is then filtered and run off into large troughs, about 10 feet long by 6 feet wide, and 9 inches deep, lined with sheet copper; this liquor is then kept in a state of agitation by a wooden rake, until nearly cold. By this process a large quantity of very minute crystals are formed, which are collected as they form by a wooden hoe, and shovelled with a spade on to a framework covered with copper sieving resting on the opposite sides of the trough, and allowed to drain. These fine white crystals, which have exactly the appearance of snow, when they have drained sufficiently, are raked over in a washing cistern adjoining, which is about 6 feet long, 4 feet wide, and 3ft. 6in. deep, and fitted with a false wooden bottom that can be removed at pleasure. Cold water is allowed to run on to the saltpetre in this cistern till it is nearly level with the top. After remaining for an hour it is drained off, and filled again with fresh water, which is drained off after about another hour. The saltpetre thus obtained is perfectly pure, and equal in every respect to the treble-refined by the old method. The water remaining in the cisterns after agitation, is left till the next morning, when a quantity of larger crystals are formed on the bottom and sides; these are equal to once-refined by the old method, and are used with grough; the mother-liquor is then drained off, and evaporated in the usual way. The water from each washing is conveyed into cisterns, and used with grough saltpetre instead of water; but, as it contains a small portion of saltpetre in solution, a lesser quantity of grough is used to make the proportions correct.

The saltpetre flour, however, contains a certain degree of moisture, which has to be dried off in the following way: two large copper trays, about 10 feet by 6 feet, with a 3-inch rim, are fixed over flues heated by a furnace, 4 inches of sand being between the flues and the bottom of the trays; the saltpetre is spread about 2 inches deep all over, and raked about till dry; it is then barrelled up for use. It takes about two hours to dry 5 cwt.

Drying.

On comparing the two systems, there cannot for one moment be a doubt as to the immense advantages of the latter over the former. As an example, in the refinery where this new process is carried on, the result (that is to say, pure saltpetre) is obtained in one day instead of six, with less than one half the amount of labour and coals.

Comparison
of the two
methods.

On reflection, the reason of the great gain of time by this process will suggest itself. In the former method, when allowed to remain quiet, the crystals formed are very large, and the spaces left in them always contain a certain amount of mother-water, which necessitates its being crystallized three times to perfectly free it from the liquor. In the latter, the crystals are so minute that there is practically no space for the mother-water to collect; consequently, by careful washing, the saltpetre is obtained perfectly pure.

Why new
method best.

CHARCOAL.

Wood charcoal is the woody fibre that remains after the liquid and more volatile parts have been driven off by the fire in the process of charring. The tempera-

Charcoal.

Object of charring.	ture resulting from the combustion of charcoal is much higher than that from burning wood, in consequence of the absence of the large quantity of water which wood contains, amounting to between 50 and 60 per cent.; the object, therefore, of charring wood is the removal of moisture, and also, what is of great importance, the expulsion of those matters contained in it which become volatile before they are burned, thus rendering a large amount of heat latent. The woods generally used in this country in making charcoal for gunpowder are the alder, willow, and dogwood. There are about 60 acres of wood grown for charcoal at Waltham Abbey. The alder is cut every eight years, and the willow in six years. It is used after one year. Other woods are sometimes used by English and foreign manufacturers, but none produce a powder of such quality as obtained from the above. It is usually considered that better charcoal is distilled when the wood is allowed to season for a time; but recent experience has shown that wood only lately cut and peeled, after being desiccated in a hot chamber, will make equally good charcoal with that which has been seasoning for three or four years.
Best wood for charcoal.	
First process.	All the wood which is cut in the Government grounds or purchased from merchants, is stripped of the bark, on account of its being impregnated with salts and gummy substances, cut into lengths of 3 feet for the convenience of loading the iron slips, which are a little above this length, and stacked in the wood-yard.
Cylinder charcoal.	Cylindrical cases of the required size, fitted with lids, are filled with wood. These cases are made to fit easily, and slide horizontally into iron retorts built in the wall, which admit of the accurate regulation of heat (communicated to them by furnaces underneath) throughout the operation of charring. A great saving of time and heat is effected by their use, as when the wood has been properly charred the case or slip containing it may be easily withdrawn, and another containing a fresh charge at once introduced into the retort, without allowing the latter to cool down, as would otherwise be necessary. When it has been sufficiently charred (which is known by experience, in watching the burning of the gas that is produced and is conducted into the fire), the slip is withdrawn by tackling, and at once lowered down into iron coolers or cases, which are immediately covered up with close-fitting lids, and then allowed to remain until all fire is extinguished. The goodness of charcoal is an essential point in the manufacture of gunpowder. About twenty-five to thirty per cent. is obtained; and one cord will produce about four cwt. of charcoal. If properly charred, it should have a jet black appearance, and when powdered a lustre resembling velvet; it should be light and sonorous when gently dropped, and its fracture should exhibit the same appearance throughout; it should be so soft as not to scratch polished copper, and ought not to exhibit any alkali when treated with pure distilled water. Charcoal is very porous, and absorbs very greedily gases and moisture from the atmosphere; no large store therefore is ever kept, and particular care is taken to prepare it only in proportion as it is required for use. At all times it must be kept exceedingly dry; when whole it will absorb about eight per cent. its weight of moisture, and when in powder 15 per cent., so that the fresher the charcoal is the better for the powder.
Quantity produced.	
Qualities.	
Kept dry.	
Absorbs.	

SULPHUR.

Sulphur is a simple, combustible, solid, non-metallic, elementary body. It is found generally in great quantities in the neighbourhood of volcanoes. It is also obtainable from metallic ores, and readily fuses. At 170° Fahrenheit it begins to evaporate; at 185° to 190° it melts; at 220° it is perfectly fluid; and at 600° it sublimes. Sulphur is purified simply by melting: that which is supplied to Waltham Abbey has been once refined, and the following is a description of the apparatus and method for purifying and rendering it fit as an ingredient in Gunpowder. A large iron pot is set about three feet off the ground, or about the height that an ordinary boiling copper is placed, having a furnace underneath. This pot has a movable lid, which is fixed into the top of the pot with clay, and in which lid is an iron conical plug that can be removed at pleasure. From the pot lead two pipes, one to a large circular dome, and another to an iron retort, rather below its level. The last-mentioned pipe has a casing, or jacket, round it, which can be filled with cold water. The communication of these pipes with the melting pot can be shut off or opened, as occasion requires, by a mechanical arrangement. About 5½ to 6 cwt. of the once-refined sulphur is broken up into small pieces, placed in the iron melting pot, and subjected to the action of the furnace. The plug in the lid, and the pipe leading to the dome are now left open, but the pipe to the retort closed. After from two to three hours a pale yellow vapour rises, when the plug is put in, and the vapour conducted into the dome, where it condenses in the form of an impalpable powder, commonly called flowers of sulphur. A small pipe leads from the bottom of the dome, on the opposite side, into water, to allow the escape of the air, and sulphuric acid is taken up by this water. In about one and a half to two hours after, the vapour becomes of a deep iodine colour, when the communication with the dome is shut, and the one to the retort opened; at the same time, cold water from a tank above is allowed to pass into the jacket we have before mentioned, surrounding this pipe. The vapour then which distils over is condensed in the pipe, and runs into the retort below in the form of a thick yellow fluid. When nearly all has distilled, which can be known by the jacket getting cold, the communication is again closed with the retort, and the fluid sulphur left an hour, to get sufficiently cool to ladle out into moulds, the furnace door and the communication with the dome at the same time are again thrown open, that the rest of the vapour may pass into the latter. The flowers of sulphur thus obtained are used for laboratory purposes, being unfit for the manufacture of Gunpowder, from the acid they contain, and the crystalline sulphur, after being allowed to cool in the moulds, is barrelled up and used as the third ingredient in Gunpowder.

Sulphur.

How purified.

Flowers of sulphur unsuitable.

PULVERIZING THE INGREDIENTS.

The three ingredients are now ground separately to a very fine powder. The mills (vide plate 1) which effect this, and incorporate, are so similar, that a description will be given under the head of "Incorporation." After being ground in this

Grinding.

Screening.

way, the saltpetre is passed through a slope cylindrical reel, covered with copper sieving wire of 60 meshes to the inch, which, as it revolves, sifts it to the required fineness, being then received in a box or bin underneath. The charcoal and sulphur are likewise passed through similar reels of 32 and 60-mesh wire respectively, and that which remains without passing through, is ground again under the runners. A very excellent machine has been invented by Mr. Hall, the engineer, of Dartford, for grinding charcoal, which makes a most useful addition to the Gunpowder factory. It consists of a conical drum, working in a conical box, on the same principle as a coffee-grinding machine, the axis being vertical. The mill is fed with charcoal by a hopper, and, as it passes through in fine powder, falls into a revolving reel, which sifts it in the same manner as before described, the whole being covered in, to prevent the great annoyance of dust, which was felt until lately, from the old charcoal mill. The three ingredients having been pulverized, are now fit for the mixing process.

MIXING THE INGREDIENTS.

Mixing and proportions.

The ingredients are now weighed out very accurately, in the proportion of 75 nitre, 15 charcoal, and 10 sulphur, in 42lb. charges, viz., nitre, 31lbs. 8oz., charcoal, 6lbs. 4oz. 13drs., sulphur, 4lbs. 3oz. 3drs., and thoroughly mixed in a machine, which consists of a cylindrical gun-metal or copper drum, about two feet in diameter, with an axle passing through its centre, on which there are metal flyers, like forks. The machinery is so arranged that the flyers and drum revolve in opposite directions when in motion, at a rate of about one hundred revolutions per minute. Five minutes is sufficient for a thorough mixture. The composition is then drawn off by a slip into canvas bags the proper size to hold the 42lb. charges, which are tightly tied, and taken to small magazines. These are called green charges, and are now ready for the next process, incorporation.

Green charges.

THE INCORPORATING MILL.

Incorporation

The Incorporating Mill consists of an iron or stone circular flat bed, about seven feet in diameter, fixed very firmly in the floor of the building which covers it, whereon two iron or stone cylindrical runners, from five to seven feet in diameter, fourteen to eighteen inches wide, and each weighing from 3 to $4\frac{1}{2}$ tons, revolve. They have a common axle, and a vertical shaft passing through the centre of the bed is connected with this axle, and to machinery above or below, which communicates the motion. These runners are not equidistant from the centre, by which arrangement in their revolution every part of the composition on the bed is subjected to their action, which is threefold, viz., crushing, grinding, and mixing; crushing, from the weight of the cylinders; grinding, from the twisting motion which they are forced into from so large a diameter revolving in so small a circle; and mixing, from a combination of the two former motions. To prevent the powder from falling over the side of the bed, a wooden rim, about two feet in height, is placed at an angle of forty-five degrees with it, like the side of a funnel, and fitted closely all round its circumfer-

ence. This is called the "curb;" and in the centre of the bed a gun-metal ring, or "cheese," as it is termed, about two feet in diameter, and five inches high, concentric with the bed, prevents the powder working beyond in that direction. Moreover, two scrapers, or "ploughs," connected by stays with the horizontal axle, revolve with the runners, one rubbing against the inner, and the other the outer circle. These ploughs are made of hard wood, shod with leather and felt, and their use is continually to disturb and rout about the composition, and keep it under the path of the runners, so that every part should get its share of incorporation. The houses or sheds which cover these buildings have hitherto been constructed of wood, with either corrugated iron or wooden roofing. The new incorporating mills in this factory, which are just completed, are built with three sides of strong three-foot brickwork, and the fourth side and roof of corrugated iron and glass. They are also placed in a line contiguous to each other, the alternate ones only facing the same way, so that an explosion from one would probably communicate no further, and the lighter parts of the building would blow away, leaving the rest entire. Most of the machinery in the factory is driven by water-wheels; the motive power of these mills is steam. A horizontal shaft, worked by the engine, passes underneath the entire length of the building in a cast-iron tank, and a bevel wheel on this shaft is geared into another one on the vertical shaft under the centre of each bed, which, communicating with the runners, gives the necessary motion.

In order, as much as possible, to guard against any explosion spreading, above each bed, placed so as just to clear the runners, is suspended or balanced a copper tank, holding about forty gallons of water. On one side of the tank is fixed a small shaft, which communicates with similar cisterns over the beds of the mills on either side. The other end of the tank rests on a flat board, which is subjected to a great part of the force of an explosion. This consequently lifts, disengaging the support of the tank, the contents of which drench the bed which has just exploded, thereby putting out all fire, and cooling the machinery, besides having a similar effect on the mills right and left, preventing, by this means, any extension of fire.

Water-tanks
to prevent
explosions.

INCORPORATING THE INGREDIENTS.

The charge is spread pretty evenly over the surface of the bed, and moistened with from four to six pints of distilled water; the quantity varying according to the state of the atmosphere; the runners are then set in motion, and run from seven to eight revolutions per minute for three and a half hours, during which time the powder is often routed up by a copper-shod spud, and watered slightly with a fine rose watering pot, according to the experience of the millman; at the end of this time the mixture is thoroughly incorporated, possesses all the chemical properties of Gunpowder, and is taken off the bed in the form of a cake, varying from a quarter to half an inch in thickness, and of a blackish-grey colour. This is called "Mill Cake," and when broken, the fracture should exhibit the same uniform appearance, without presenting any sparkling or yellow specks; should this, however, be the case, it is a

Incorporation

Mill cake.

Proof of mill cake.	sign of the ingredients not being sufficiently incorporated. In this stage it undergoes certain proofs; samples of the cake are taken from every charge that is worked, dried in an oven, and granulated; half a drachm of this is fired in a vertical eprouvette, which it ought to raise 3.5 inches; and half an ounce is flashed on a glass plate. If very little residue or ash is left, it is an additional proof of its being well incorporated, and that the millman has done his work properly.
Importance of incorporation	Incorporation is by far the most important process in the manufacture of Gunpowder; for, however carefully the other part of the fabrication is carried on, should there be a failing in this, the powder will be worth nothing.
Object of manufacture.	The great and ultimate object to be attained in the manufacture of Gunpowder is, to produce that which shall give equal results with equal charges; the greatest regularity should therefore be observed in this stage. The millman should have great experience; the runners and beds should be, as nearly as possible, the same size and weight, and driven at the same speed throughout the factory; at any rate, each charge should be worked to the same number of revolutions; the motion of the runners should also be as uniform as possible, which is very satisfactorily accomplished by each water-wheel being regulated by a governor.

BREAKING DOWN THE MILL CAKE.

Breaking down the mill cake.	The mill cake, after it comes off the bed of the incorporating mill, is placed in wooden tubs, and taken to small-expense magazines, and from there, in about twelve hours, to the breaking-down house; the object of the machine from which this takes its name, is to reduce the cake to a convenient size for the hydraulic-press box, and also that, by being crushed again to meal, it may get a more even pressure. It consists of a strong gun-metal framework, in which are fixed two pairs of fine-toothed or plain rollers, which revolve towards each other, working in spring collars, so that on any hard substance getting in by mistake, they would open, and allow it to pass through, thereby preventing the dangerous friction which would otherwise result. A hopper, or upright wooden funnel, capable of holding about 500 lbs. is fixed at one end of the machine, and an endless canvass band 2ft. 6in. wide, having strips of leather sewn across at intervals of four inches, passes over one roller at the bottom of the hopper, and one at the top of the machine. When set in motion, this conveys the cake from the hopper to the highest point of the band; it then falls through the first pair of rollers, and from thence through the second, passing in the form of meal into small wooden carriages underneath, which, as they are filled, move forward by a self-acting motion, making room for others. The mill cake thus broken down, is fit for the press.
Object of mealing.	

PRESSING THE MEAL BY THE HYDRAULIC PRESS.

Hydraulic Pressure.	The meal is now subjected to very powerful pressure; and, in order to explain the way in which this is effected, a short description of the apparatus must be given.
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The principle of the hydraulic press is so familiar to most, that it will be unnecessary to do more than show how the power is applied (vide plate 2).

A very strong oak box, 2 feet 6 inches square, and 2 feet 9 inches deep, is constructed so that two of the sides of the lid will fall back on hinges, or form a compact solid box when screwed firmly together. Forty-six copper plates, 2 feet 5½ inches square, slide vertically into this box, and are kept five-eighths of an inch apart by two metal slips with corresponding grooves, which can be removed when necessary.

About 800lbs. of the meal is put into this box while the plates are in the position we have described. When full, the slips are withdrawn, the plates being then only separated by the powder between them: the lid is now firmly screwed down, and the box turned over by an arrangement of pulleys, so that the plates which were vertical will now be horizontal. The present upper side is then unscrewed, and a travelling crane, moving on a rail overhead, is lowered till the claws attached to it hook on to two trunnions fixed on the sides of the box; it is now hoisted by means of a handwheel windlass, and the box being suspended, is pushed easily by means of the rail, and deposited in this position on to the table of the ram under the press block. The pumps are now set in motion by a water-wheel, and are allowed to work up to the required pressure, which is about seventy tons to the square foot; it is then conveyed from under the block in the same manner, and very easily unloaded. The press cake is then taken out in layers between each plate, resembling dark pieces of slate, about half an inch in thickness. After a day or so, this hardens so much as to be difficult to break, and the appearance of the fracture resembles that of the finest earthenware. Many important advantages are gained by this pressure, of which the following are the principal:—

First, the density of the powder is increased, which prevents it falling to dust in transport, or by rough usage. Secondly, its keeping qualities are improved, for it withstands the action of the atmosphere, and absorbs less moisture than a porous light powder. Thirdly, it produces more grain in the manufacture than mill cake; and a less proportion, consequently, is lost in dust. Fourthly, a closer connection of the ingredients is obtained. Fifthly, a greater volume of inflammable gas is produced from a certain bulk, than from a corresponding bulk of lighter powder.

The range, however, is lessened, from a greater quantity being blown out of a gun unignited; but this small loss is more than counterbalanced by the former advantages, and actually it is only perceptible in newly-made powder; for a light, porous powder soon loses its superior range from its absorption of moisture, while that of the dense powder remains unaltered.

Description of
box.

Quantity
pressed.

Amount of
pressure.

Reasons for
pressure.

Disadvan-
tages of pres-
sure.

GRANULATING THE PRESS CAKE.

The next process is granulation, or reducing this press cake into the proper sized grain for cannon, musket, or rifle powder. The machine which effects this is very beautifully contrived, and is entirely self-acting, obviating the necessity of any one being in the building while it is in motion. It resembles, in appearance and action,

Mode of
granulation.

Screening.

the breaking-down machine, except that it is larger, and is fitted with three pairs of toothed rollers, of different degrees of fineness, working in the same kind of collars already mentioned, so that, on any hard substance passing through, they would open accordingly, and thus prevent friction. At one end of the machine is a wooden hopper, or funnel, which is filled with the press cake. This is contrived so as to rise gradually by the motion of the machine, and constantly to supply an endless band, similar to the one described in the breaking-down house. When the cake arrives at the highest point of this band, it falls over, and is granulated between the first pair of gun-metal rollers. Under each pair is a screen, covered with 8-mesh wire. All that is not sufficiently small to pass through, is carried on to the next pair of rollers; and, in like manner, that which does not pass through the second screen is carried to the third pair. In addition to these screens, there are three oblong sieves covered with 8- and 16-mesh wire, and 56 cloth respectively, fixed under, and parallel to, each other, each being separated by about four inches of space, running at an incline just below the three pairs of rollers; these all lead to little wooden carriages placed on the opposite side of the machine, which are divided so as to collect the different sized grain as it passes down. To facilitate the separation and sifting of the powder, and to prevent masses of it forming and clogging up the wire, a shaking motion is imparted by a circular wheel attached to the framework of these sieves revolving against an octagonal one fixed to the machine. The grains which pass through each screen below the rollers fall on the upper one of these three last-mentioned sieves. That portion which passes through this, and is retained on the 16-mesh wire, is cannon powder; that passing through the 16-mesh sieve, and retained on the 56-cloth, is fine grain; and a board, running also parallel underneath, retains the dust that passes through the cloth.

Chucks
regranulated.

The "chucks," as they are called, or those grains that are too large to pass through these different sieves, are collected in the same way as the grain, and undergo the process of granulation again.

DUSTING LARGE-GRAIN POWDER.

Object of
dusting.How per-
formed for
large-grain.

The keeping qualities of powder are very much improved by removing the dust, which quickly absorbs moisture from the atmosphere. This operation, for large-grain, is performed by cylindrical reels, about 8ft. 6in. long, and 3ft. 8in. in diameter, clothed with 28-mesh canvas, which revolve at the rate of thirty-eight times per minute. Those for large-grain are called horizontal reels, in contradistinction to those for fine-grain, that are called slope reels. Each is enclosed by a wooden case, to prevent the dust flying about the house. When the powder has run its time, one end of the reel is lowered. It then runs out into barrels placed to receive it. This entirely separates the dust, and imparts a fine black gloss, which is sufficient glazing for the large-grained powder.

Glazed at
same time.

DUSTING FINE-GRAIN POWDER.

The fine-grain powder has a much greater proportion of dust when it leaves the granulating house than the large-grain, and it is found necessary, on this account, to use a different kind of reel. They resemble those for the former powder, except that they are covered with 44-mesh canvas instead of 28, and are placed at an incline which prevents their being choked up with the quantity of dust; each end is also open, and a continuous stream of powder, fed by a hopper, passes through while they revolve, and pours out at the lower end into barrels. This process is repeated a second time, which sufficiently frees it from dust.

Dusting fine-grain.

GLAZING FINE-GRAIN POWDER.

The fine-grain powder thus dusted, is then glazed for three hours in barrels capable of holding 300lbs. which are 3ft. 6-in. in length, and 2ft. 8-in. in diameter, revolving at the rate of thirty two times in a minute. By the mere friction of the grains against each other and the inside of the barrel, a glaze is imparted, presenting a fine polished surface to the grain.

Glazing fine-grain.

Powder glazed in this way withstands the action of moisture to a far greater extent than unglazed powder, and in transport very little dust is formed.

Object of glazing.

STOVING OR DRYING POWDER.

A drying-room, heated by steam pipes, is fitted with open framework shelves, on which rests small wooden trays about 3ft. long, 1ft. 6-in. in breadth, and 2½ in. deep, having canvas bottoms; on each is spread 8lbs. of powder. This room holds about 40 barrels, or 4,000lbs., which remains in it for twenty four hours, and is subjected to a heat of 130° Fahrenheit for sixteen hours, communicated by steam passing through pipes arranged horizontally on the floor of the room. The temperature is raised and lowered gradually, otherwise the too sudden change would be likely to destroy the texture of the grain. The ceiling and roof are fitted with ventilators, through which all the moisture escapes, so that there is a constant current of hot air circulating through the room. It is of the greatest importance that the vapour should be carried off; for, if this is not effectually done, on the decrease of temperature, it would return to its liquid state, and form again on the powder.

Drying.

FINISHING DUSTING.

The action of heat however produces a small portion of dust; both these powders, therefore, when they leave the stove, are reeled in horizontal reels, clothed with 28 and 44-mesh canvas respectively, for one hour and a half. This perfectly separates any remaining dust, and gives the finishing glaze to the large-grain powder. This is the final process, and the powder thus finished is taken to the barrelling-up house; weighed out into barrels holding 100lbs. each; marked L. G. (large-grain), and F. G. (fine-grain), as the case may be; and stored in magazines.

Final dusting.

Barrelling.

EXAMINATION AND PROOF OF GUNPOWDER.

Desired
properties of
gunpowder.Specific
gravity.

Strength.

Purity.

The great and ultimate object to be attained in the manufacture of Gunpowder is, not so much to produce that which ranges the highest, as one that shall be durable in its texture, not easily deteriorated by atmospheric influence or transport, and one with which equal charges shall produce equal effects. It should present uniformity in the appearance of its grains, which should be angular, crisp and sharp to the touch, not easily reduced to dust by pressure between the fingers, or dusty in handling; its specific gravity should not be under 55lbs. to the cubic foot, (that of Waltham Abbey is generally 58lbs.) taking water at 1000ozs.; its strength is tested by firing three rounds from an 8 inch mortar, throwing a 68-pounder solid shot with a charge of 2oz. this should give a range of from 270 to 300 feet. The distance however, varies considerably, according to the state of the atmosphere, and the density of the powder: for, the greater the density, the less the range in small charges. Half an ounce flashed on a glass plate should leave little or no residuum; should white beads or globules appear, it is a sign of imperfect incorporation.

PROOF OF MERCHANT'S POWDER.

The following are the different proofs merchant's powder is subjected to:—

Lots of 100 barrels are sent in, marked with the number of the lot and the maker's name on the head of each barrel. 25 per cent. of these are unheaded in the examining house; the Proof Officer then—

If dusty.

First, takes a bowl out of each barrel, and holding it about three feet above, pours it out quickly; should there be a good deal of dust, it is satisfactorily shown by this means.

Firmness.

Secondly, it is handled and pressed between the fingers, to test the firmness of its grain; and should there appear to be any great difference in the proportions of different sizes to that laid down as a standard, it is sifted and compared accordingly, being rejected should the quantities fall short or exceed the sample in any great degree.

Size of grain.

Density.

Thirdly, a barrel or two are selected, and the powder poured into a hopper, under which is placed a box very carefully constructed, so as to hold exactly a cubic foot. A slide is now withdrawn at the bottom of the hopper, and the powder allowed to run into the box in a continuous even stream until it is piled up; the hopper is then removed, and the powder struck off with a straight edge, level with the top of the box. The weight is now carefully taken, that of the latter being subtracted; should this not amount to 55lbs. it is rejected, as not being of sufficient density.

Strength by
range.

Fourthly, samples are taken from every barrel, and lot for the firing proof.

Firing Proof.—An average of nine rounds of sample Waltham Abbey powder is taken, three rounds being respectively fired at the beginning, middle, and end of the proof, from the same kind of mortar before mentioned, with a charge of 2oz. An average of three rounds of each lot of the merchant's powder is also taken; should it fall short by more than 1 in 20, it is rejected.

Fifthly, to ascertain if any residuum or ash is left after ignition, about half an ounce is burned on a clean glass plate, and fired with a hot iron. The explosion should be sharp, and produce a sudden concussion in the air; and the force and power of this concussion should be judged by that of known good quality. Few sparks should fly off, nor should white beads or globules appear, as it would be a sure indication, as we have before explained, of insufficient incorporation. It is also subjected to a second proof.

Purity by
flashing.

Second proof.—A sample of 1lb. from each lot, carefully weighed up, and a similar sample of the comparison powder, is exposed for three weeks in a box perforated with holes (called a damp chest), to the action of the atmosphere. This box is placed under cover, so that it is sheltered from the wet, but that the moisture can get to it. If, at the end of this time, there is a greater proportion of difference in range between them than one-twentieth, it is rejected. The pounds are also very carefully weighed up again, to ascertain the comparative absorption of moisture. This is called the hygrometric test.

Purity by
weight after
exposure to
damp.

REMARKS ON THE PROOF OF POWDER BY THE EPROUVETTES.

By comparing the results of the proofs by the epreuves with those furnished by the cannon pendulum (vide plate 1, fig. 2 and 3), it will appear that the epreuves are entirely useless as instruments for testing the relative projectile force of different kinds of powder, when employed in large charges in a cannon. Powders of little density, or of fine grain, which burn most rapidly, give the highest proof with the epreuves, whilst the reverse is nearly true with the cannon.

By epreuves
of
pendulum.

The only real use of these epreuves is to check and verify the uniformity of a current manufacture of powder, where a certain course of operations is intended to be regularly pursued, and where the strength, tested by means of any instrument, should therefore be uniform.

Real use of
eprouvettes.

The only reliable mode of proving the strength of Gunpowder is, to test it with service charges in the arms for which it is designed; for which purpose the ballistic pendulums (vide plate 3), are perfectly adapted.

Best proof, by
service
charges.

For the proof of powder for small arms, the small ballistic pendulum is a simple, convenient, and accurate instrument.

Best proof for
small arms.

The common epreuves are of no value as instruments for determining the relative force of different kinds of Gunpowder.

Common
eprouvette.

OF THE SIZE OF GRAIN FOR GUNPOWDER.

With regard to the particular size of grain for Gunpowder, I am confident great improvements might be made, both in obtaining greater regularity of effect and propelling force, by the adoption of a more uniform even grain. There are at present half-a-dozen different sizes in our cannon and musket powder; and I think it stands

On size of
grain.

to reason, that the more equal the size, the more uniform will be the ignition of all the grains, and consequently the effect of the same charges will be much more regular.

OBSERVATIONS ON THE MANUFACTURE OF GUNPOWDER ON THE CONTINENT AND AMERICA.

It may not be uninteresting to have a slight knowledge of the method employed on the Continent, &c., for the production of Gunpowder.

Proportion of
the ingre-
dients.

The proportions of the three ingredients vary slightly all over the Continent and America, being as follows:—

	SALTPETRE.	CHARCOAL.	SULPHUR.
France	75	12.5	12.5
Belgium			
Russia	73.78	13.59	12.63
Prussia	75	13.5	11.5
Austria	75.5	13.2	11.3
Spain	76.47	10.78	12.75
United States.....	76	14	10

PRODUCTION AND PURIFICATION OF THE INGREDIENTS.

Production
and purifica-
tion of the
ingredients.

The nitre is purified in a similar way to the new method employed at Waltham Abbey, though it is seldom obtained with so faint a trace of chlorides, owing probably to its being of an inferior quality, and of higher refraction when it is imported.

The sulphur is supplied to the manufactories in France in the form of roll sulphur, from Marseilles and Bordeaux, where there are very large refineries.

The charcoal is prepared from dogwood, alder, willow, hazel, and poplar, sometimes in pits, and occasionally in cylinders, as at Waltham Abbey. At Wetteren, and in some parts of France, it is distilled by the action of steam. The “charbon roux” taking its name from its brownish-red tinge, from being only partially burned, was used formerly more than now, as the powder made from it was found to injure and exert very pernicious effects upon fire-arms.

PULVERIZING AND MIXING THE INGREDIENTS.

Pulverizing
and mixing
the ingre-
dients.

The ingredients are generally pulverized in copper drums, capable of holding 224 kilogrammes. Part of the charcoal is mixed with the sulphur, and part of the sulphur with the saltpetre. They are then put into separate drums, which revolve about twenty-five times per minute for three hours, and in which are about 500 gun-metal or bronze balls, the size of good large marbles. The ingredients are brought to the most minute state of division by these means, and are then mixed altogether, for one hour, in similar drums covered with leather, containing wooden balls.

INCORPORATING PROCESS.

The fine powder thus obtained is sometimes merely moistened, so as to form a stiff paste, and passed through rollers, the cake formed, being dried and granulated. The incorporating cylinders are used occasionally, but the more usual plan adopted on the Continent to effect this operation is the stamping-mill, which requires a short description. It is nothing more nor less than the pestle-and-mortar principle, each mill consisting of from six to twelve bronze or wooden mortars bedded in the floor of the building; they are the shape of the frustrum of a cone, the mouth being much narrower than the base; the pestles, or stampers as they are called, are made of wood, shod with either very hard wood or bronze, on which project wooden teeth about twelve inches long; a vertical movement is imparted to them by a shaft worked by the water-wheel having similar teeth attached; in its revolution it raises the stamper about eighteen inches, which falls again as the projection is disengaged, twenty five times in a minute. This operation is carried on for twelve hours, during which period the charge (about 15lbs.) is moistened at intervals, and routed up with a copper-shod spud; at the end of this time the cake is taken out, and left to dry and harden; it seldom receives any pressure—although, in some manufactories, presses are being erected.

Incorporation

GRANULATING.

The cake is then granulated in sets of sieves fitting one into the other, having perforated zinc bottoms of different degrees of fineness, which are suspended from the ceiling of the room by ropes, an ash spring being attached to each box holding the sieves, the cake is put into the uppermost one with some gun-metal balls, and shaken backwards and forwards, which motion the spring facilitates; it is thus broken up into different sized grains, which are separated by passing through the several meshes.

Granulation.

The grain formed is then dusted in bags or shaking-frames covered with canvas, and then glazed in barrels.

STOVING OR DRYING.

Drying.

In summer the process of drying is often performed in the sun, and in winter by the steam stove, in the following way. The powder is spread about three or four inches thick on a large canvas tray, under which is an arrangement of pipes, which convey the hot air forced by a fan through a cylinder heated by steam: it is considered to be sufficiently dried in from three to four hours, during which time it is occasionally raked about. In some manufactories it undergoes a further operation of being dusted, and is then barrelled up for use. Generally the great failure in the foreign manufacture is the neglect of the principal stage of the fabrication, viz. incorporation; with the old stamping-mill, it is quite impossible that the process can be carried out to the necessary extent. The Continental powder is usually very soft in

Comparative

merits of
foreign and
English gun-
powder.

its grain, dusty, and quickly absorbs moisture from the atmosphere; its density is below the English powder, on account of its never being subjected to pressure; consequently it is not so durable, and forms a good deal of dust in transport; a great amount of residue is generally left in the gun, and its strength, as a propelling agent, is far inferior to our powders. On being flashed on a glass plate, instead of producing a sudden concussion, like the sharp rap of a hammer, it burns more like composition, throwing off a quantity of sparks.

NEW RIFLE POWDER.

The following mode of manufacturing rifle powder, appeared in Garrison Orders at Woolwich, 31st December, 1859:

Composition in 100 parts:—

Saltpetre	75
Charcoal	15
Sulphur	10
	100

The charcoal to be prepared from dogwood, burned slowly in cylinders three hours. The composition to be worked under the runners for five and a half hours, and submitted to a pressure of about 50 tons to the square foot. The size of the grain to be that collected between sieves of 16 and 24 meshes. The grain to be glazed for five hours.

NOTE.—The foregoing, on the manufacture of gunpowder, is principally taken from an article in the Aide Memoire (1860), by Major Baddeley, Royal Artillery; Captain Instructor, Waltham Abbey.

ON MAGAZINES.

It is impossible to make powder magazines too dry, and every care should be taken to ventilate them as much as possible during dry weather, by opening all doors, windows, loopholes, &c. Magazines are generally made bomb-proof, and are furnished with lightning conductors. They are divided into chambers, and these again divided by uprights into bays. At Purfleet, which is the grand dépôt for gun-powder in England, there are five magazines capable of containing 9,600 whole barrels each. Each magazine is divided into two chambers, and each chamber into 24 bays, and in each bay is placed 200 whole, 400 half, or 800 quarter barrels of powder. Total in the five Magazines, 48,000 barrels, equal to 4,800,000 pounds.

LIGHTNING CONDUCTORS.

Principles and Instructions relative to their application to Powder Magazines, by SIR
W. SNOW HARRIS, F.R.S. *Extracted from Army List for July, 1859.*

1.—Thunder and lightning result from the operation of a peculiar natural agency through an interval of the atmosphere contained between the surface of a certain area of clouds, and a corresponding area of the earth's surface directly opposed to the clouds. It is always to be remembered that the earth's surface and the clouds are the terminating planes of the action, and that buildings are only assailed by Lightning because they are points, as it were, in, or form part of, the earth's surface, in which the whole action below finally vanishes. Hence buildings, under any circumstances, will be always open to strokes of Lightning, and no human power can prevent it, whether having Conductors or not, or whether having metals about them or not, as experience shows.

2.—Whenever the peculiar agency, (whatever it may be), active in this operation of nature, and characterized by the general term Electricity, or Electric Fluid, is confined to substances which are found to resist its progress, such, for example, as air, glass, resinous bodies, dry wood, stones, &c., then an explosive form of action is the result, attended by such an evolution of light and heat, and by such an enormous expansive force, that the most compact and massive bodies are rent in pieces, and inflammable matter ignited. Nothing appears to stand against it. Granite rocks are split open, oak and other trees, of enormous size, rent in shivers, and masonry of every kind frequently laid in ruins. The lower masts of ships of the line, 3 feet in diameter, and 110 feet long, bound with hoops of iron half an inch thick and 5 inches wide, the whole weighing about 18 tons, have been, in many instances, torn asunder, and the hoops of iron burst open and scattered on the decks. It is, in fact, this terrible expansive power which we have to dread in cases of buildings struck by Lightning, rather than the actual heat attendant on the discharge itself.

3.—When, however, the electrical agency is confined to bodies; such as the metals, which are found to oppose but small resistance to its progress, then this violent expansive or disruptive action is either greatly reduced, or avoided altogether. The explosive form of action we term Lightning, vanishes, and becomes, as it were, transformed into a sort of continuous current action, of a comparatively quiescent kind,

which, if the metallic substance it traverses be of certain known dimensions, will not be productive of any damage to the metal. If, however, it be of small capacity, as in the case of a small wire, it may become heated and fused. In this case, the electrical agency, as before, is so resisted in its course as to admit of its taking on a greater or less degree of explosive and heating effect, as in the former case. It is to be here observed, that all kinds of matter oppose some resistance to the progress of what is termed the Electrical Discharge, but the resistance through capacious metallic bodies is comparatively so small, as to admit of being neglected under ordinary circumstances; hence it is that such bodies have been termed Conductors of Electricity, whilst bodies such as air, glass, &c., which are found to oppose very considerable resistance to electrical action, are placed at the opposite extremity of the scale, and termed Non-conductors or Insulators.

The resistance of a metallic copper wire to an ordinary electrical discharge from a battery, was found so small, that the shock traversed the wire at the rate of 576,000 miles in a second. The resistance however, through a metallic line of Conduction, small as it be, increases with the length, and diminishes with the area of the section of the Conductor, or as the quantity of metal increases.

4.—It follows from these established facts, that if a building were metallic in all its parts, an iron magazine for example, then no damage could possibly arise to it from any stroke of Lightning which has come within the experience of mankind; e.g., a man in armour is safe from damage by Lightning; in fact, from the instant the electrical discharge in breaking with descriptive and explosive violence through the resisting air, seizes upon the mass in any point of it, from that instant the explosive action vanishes, and the forces in operation are neutralized upon the terminating planes of action, viz., the surface of the earth, and opposed clouds.

5.—All this plainly teaches us, that in order to guard a building effectually against damage by Lightning, we must endeavour to bring the general structure as nearly as may be, into that passive or non-resisting state it would assume, supposing the whole were a mass of metal.

6.—To this end, one or more conducting channels of copper depending upon the magnitude and extent of the building should be systematically applied to the walls; these conducting channels should consist either of double copper plates united in series one over the other, as in the method of fixing such Conductors to the masts of Her Majesty's Ships, the plates being not less than $3\frac{1}{2}$ inches wide, and of $\frac{1}{16}$ th and $\frac{1}{8}$ th of an inch in thickness, or the Conductors may with advantage be constructed of stout copper pipe not less than $\frac{3}{16}$ ths of an inch thick, and $1\frac{1}{2}$ to 2 inches in diameter: in either case the Conductors should be securely fixed to the walls of the building, either by braces, or copper nails, or clamps; they should terminate in solid metal rods above, projecting freely into the air, at a moderate and convenient height above the point to which they are fixed, and below they should terminate in one or two branches leading outward about a foot under the surface of the earth; if possible, they should be connected with a spring of water or other moist ground.

It would be proper in certain dry situations, to lead out in several directions under the ground, old iron or other metallic chains, so as to expose a large extent of metallic contact in the surface of the earth.

7.—All the metals in the roof and other parts of the building of whatever kind, should so far as possible have metallic communication with these Alarm Conductors, and in case of any prominent elevated chimney, it would be desirable to lead a pointed conducting tube along it to the metals of the roof; all of which satisfies the conditions above specified.

8.—Remark 1.—It is now proved beyond all questions, that the electrical discharge never leaves perfect conducting lines of small resistance, in order to pass out upon bad conducting circuits, in which the resistance is very great, that is an established law of nature; hence a stroke of Lightning upon such conducting lines will be confined to the Conductors as constituting a line of discharge of less resistance than any other line of discharge through the building, which can be assigned. The apprehension of "Lateral Discharge" therefore, from the Conductor, is quite absurd; and is not countenanced by any fact whatever; if any doubt could possibly exist, it would be now most completely set at rest by the experience of the permanent Conductors, applied to the masts of Her Majesty's ships. In very many instances furious discharges of Lightning have fallen on the masts with a crash as if the ship's broadside had been fired, and the solid point aloft has been found melted; in all these cases electrical discharge robbed by the Conductor of its explosive violence, has traversed the line of action to the sea, through the ship, and through the copper bolts, driven through the ship's solid timbers, without the least damage to the surrounding masses, whether metallic, as in the case of the massive iron hoops on the lower masts, or not. Persons have either been close by or actually leaning against the Conductors at the time, without experiencing any ill consequence.

9.—Remark 2.—It has also been incontestably shown, that metallic bodies have not any specific attractive force or affinity for the matter of Lightning; metals are as little attractive of lightning as wood or stone. All matter is equally indifferent to Electricity so far as regards a specific attraction, hence the idea that metals attract or invite Lightning is a popular but very unlearned error contradicted by the most satisfactory evidence, and the whole course of experience; in short, we find that Lightning falls indiscriminately upon trees, rocks, and buildings, whether the buildings have metals about them or not.

10.—Remark 3.—A building that is hence clear, may be struck and damaged by Lightning without having a particle of metal in its construction; if there be metals in it, however, and they happen to be in such situations as will enable them to facilitate the progress of the electrical discharge, so far as they go, then the discharge will fall on them in preference to other bodies offering more resistance, but not otherwise; if metallic substances be not present, or if present, they happen to occupy places in which they cannot be of any use in helping on the discharge in the course it wants to go, then the electricity seizes upon other bodies, which lie in that course, or which can help it, however small their power of doing so, and in this attempt such bodies are commonly,

but not always, shattered in pieces. The great law of the discharge is,—progress between the terminating planes of action, viz:—the clouds and earth, and in such line or lines as upon the whole, offer the least mechanical impediment or resistance to this operation, just as water falling over the side of a hill in a rain storm, picks out or selects as it were by the force of gravity, all the little furrows or channels which lie convenient to its course, and avoids those which do not. If in the case of Lightning you provide through the instrumentality of efficient Conductors, a free and uninterrupted course for the electrical discharge, then it will follow that course without damage to the general structure; if you do not, then this irresistible agency will find a course for itself through the edifice in some line or lines of least resistance to it, and will shake all imperfect conducting matter in pieces in doing so; moreover it is to be specially remarked in this case, that the damage ensues, not where the metals are, but where they cease to be continued, the more metal in a building therefore the better, more especially when connected by an uninterrupted circuit with any medium of communication with the earth.

Such is, in fact, the great condition to be satisfied in the application of Lightning Conductors, which is virtually nothing more than the perfecting a line or lines of small resistance in given directions, less than the resistance in any other lines in the building, which can be assigned in any other direction, and in which by a law of nature the electrical agency will move in preference to any others.

11.—It follows from the foregoing principles, that a magazine constructed entirely of iron or other metal, would be infinitely more safe in Lightning storms than if built with masonry in the usual way; metallic roofs for magazines, with capacious metallic Conductors to the earth, would be unobjectionable, and a source of security.

Metallic gutters and ridges having continuous metallic connection with the earth are also unobjectionable.

A good method of Conductors for magazines built of masonry, would be such as already described, regard being had to the position of the building, its extent, and most prominent points, also to the nature, state, and condition of the soil, whether it be moist or dry, alluvial calcareous, or of hard rock; we must also consider the extent, disposition, and peculiar position of the metallic bodies entering into the general structure of the building, whether the roof be flat, pointed, or angular in various parts.

The pointed projecting extremities of the two Conductors, one or more as the case may be, will be commonly sufficient; but, in buildings having tall chimneys or other elevated prominent points, at a distance from the Main Conductor, it will be requisite to guard such chimneys or other parts, by a pointed rod, led along them to the metals of the roof, or directly connected with the Main Conductors, by metallic connections.

12.—Pointed terminations of the Conductors in the air, are so far important that they tend to break the force of a discharge of Lightning when it falls on them. In fact, before the great shock actually takes place, under the form of a dense explosion, a very large amount of the discharge, which otherwise would be concentrated, runs off, as it were, through the pointed Conductor; but they have no other influence.

With respect to these pointed terminations, no great care need be taken about them, except that they should consist of solid copper rod, of about three-quarters of an inch in diameter, and about a foot in length, and be united by brazing to the conducting tube, elevated at such convenient height above the walls of the building as the case may suggest.

As a support to the Conductor, when raised above the wall, we may employ a small staff or spar of wood fixed to the masonry.

13.—Copper linings to the doors and window shutters of magazines are not objectionable, if requisite, as a precaution against fire; but they are useless as a means of keeping out Lightning; on the other hand, it is not easy to conceive a case in which the explosion of the gunpowder is to be apprehended from the action of Lightning on the doors or windows. Supposing, however, such metallic linings desirable as a precaution against common cases of fire, then the masses of metal should, according to the principles already laid down, have metallic communication with the general system of conduction in the building and the Main Conductor.

ON THE EXPLOSIVE FORCE OF GUNPOWDER.

The advantages of Gunpowder, as a propelling agent, over any other explosive material are, the comparative safety attending its manufacture and transport, and the gradual nature of its decomposition when compared with those materials, such as fulminating gold, silver, mercury, &c. &c. In gunpowder, the force resulting from the rapid evolution of gas in a confined space has sufficient time to overcome the inertia of the projectile, which is not the case with other explosive materials, the conversion of which gaseous products is so instantaneous that nothing can resist the intensity of their explosive action. Other advantages suggest themselves in the use of Gunpowder, such as the comparative cheapness of the ingredients composing it, and the ease with which they may be obtained; for the sulphur and saltpetre are very abundant productions of nature, and the charcoal can be manufactured cheaply and with great facility, and if care is taken in the process of the fabrication of powder, little deterioration will take place on its exposure to heat or moisture.

Advantages
of Gunpowder

Condensed air and steam have been used as propelling agents; but the great inconvenience attending their use quite preclude the possibility of adapting them to war purposes.

Air & Steam
as propellants

As the force and effect obtained from Gunpowder is the foundation of all other particulars relating to Gunnery, we will briefly consider these points.

Force of Gun-
powder.

The action of Gunpowder is dependent upon a purely chemical process. Mr. Robins proved that the force generated by the combustion of gunpowder, was owing to an elastic gas which was suddenly disengaged from the powder, when it was brought to a certain temperature, and further that this disengaged gas had its elastic force greatly augmented by the heat evolved by the chemical action.

Upon what
the action of
powder de-
pends.

The propelling power of Gunpowder is dependent on the rapid decomposition of the nitre into its component parts; the oxygen forms carbonic acid with the carbon in the charcoal, and the heat thus generated by ignition changes both this and the nitrogen into a large volume of heated gas. In a mixture of nitre and charcoal alone, the oxidation proceeds with comparative slowness; by the addition of sulphur, an augmentation of combustibility is gained, in consequence of its igniting at a very low temperature; the sulphur, also, by its presence, renders available for the oxidation of the carbon an additional amount of oxygen, viz: that which is united with the potassium, the latter being at once converted into sulphite upon ignition of the powder.

Ingredients
are charged
with a large
volume of
heated gas.

Weight of gas evolved.

Volume of gas evolved.

Heat of gas evolved.

Pressure of gas generated.

Strength of powder not affected by density of air, but by damp.

Velocity of gas

Dr. Hutton's calculations as to:—*Volume, Temperature, Pressure.*

Temperature

Expansion.

How to calculate expansion

It appears that the weight of gas generated is equal to three tenths of the weight of the powder which yielded it, and that its bulk when cold, and expanded to the rarity of Common air was 240 times that of the powder; the barometer standing at about 30 inches. From this Robins concluded that if the fluid occupied a space equal to the volume of the gunpowder, its elastic force, when cold, would be 240 times the pressure of the atmosphere, when the barometer stands as above. Mr. Robins also considered that the heat evolved was at least equal to that of red hot iron, and he found by experiments that air heated to this temperature had its elasticity quadrupled, and therefore, that the force of gas from powder is at least four times $240=960$, or in round numbers 1,000 times as great as the elasticity of the air measured by its pressure on an equal extent of surface. From the height of the barometer it is known that the pressure of the atmosphere is about $14\frac{3}{4}$ lbs. upon the square inch, so that the pressure of the elastic gas generated by the combustion of the gunpowder upon the same area would be 14.75 by $1,000$ or $14,750$ lbs. at the moment of explosion. He found that the strength of Gunpowder was the same whatever might be the density of the atmosphere, but that the moisture of the air effected it considerably, in fact that the same quantity of powder which would give a bullet an initial velocity of 1,700 feet per second on a day when the atmosphere was comparatively dry, would upon a damp day give no more than 1,200 or 1,300 feet.

The velocity of the expansion of the gas is a most important point, upon which depends, chiefly, the peculiar value of the substance as a propelling agent. Many of the warlike machines of the Ancients produced a momentum far surpassing that of our heaviest cannon, but the great celerity given to the bodies projected from guns by gunpowder cannot be in the least approached by any other means than by the sudden production of an elastic gas. Mr. Robins found that the flame of gunpowder expanded itself when at the muzzle of the gun with a velocity of 7,000 feet per second.

It has been calculated that one cubic inch of powder is converted into 250 cubic inches of gas at the temperature of the atmosphere, and Dr. Hutton states that the increase of volume at the moment of ignition cannot be less than eight times; therefore one inch of gunpowder, if confined, at the time of explosion exerts a pressure of about 30,000 lbs. being 250 by 8 by $15=30,000$ lbs. on the cubic inch, or 5,000 lbs. on the square inch; and which at once accounts for its extraordinary power. The value of the temperature to which the gases are raised, on the explosion of the powder, has been variously estimated and it may be concluded to rise as high as will melt copper, or $4,000^{\circ}$ Fahrenheit. All gases expand uniformly by heat, the expansive having been calculated with great precision, to be $\frac{1}{480}$ th for each degree of Fahrenheit. If therefore we take Dr. Hutton's calculations of one volume of powder expanding into 250 volumes of gas at the temperature of the atmosphere, and if we suppose $4,000^{\circ}$ Fahrenheit to be the heat to which they are raised on ignition, the expansion of gunpowder would be calculated. Thus, suppose the gas to be at 60° , the temperature of the atmosphere, we must deduct 60° from $4,000^{\circ}$, which will give 3,940, being the number of degrees remaining to which it is raised, hence $1^{\circ} : \frac{1}{480}$ $temp.$ $vol.$
 $3,940^{\circ} : \frac{3,940}{480} = 8.2$, that is, each volume of gas would at a temperature of 4000° be

increased $8 \cdot 2$ in volume. Gunpowder when at the temperature of the air being expanded 250 times in volume; therefore $250 \text{ by } 8 \cdot 2 = 2,050$ as the increased expansion for each volume of gas generated by the explosion of gunpowder at the temperature of $4,000^{\circ}$ Fahrenheit. Lieut-Colonel Boxer calculates that the heat generated by good dry powder is not under $3,000^{\circ}$ Fahrenheit. It appears with our present knowledge, the absolute value of the force of gunpowder cannot be determined. Still by careful and extensive experiments no doubt a near approximation to the truth may ultimately be arrived at, so that although much has already been done by various eminent philosophers, there is still more to be accomplished; and the importance of the subject ought to act as a stimulus to the exertions of those belonging to a profession the most interested in the question.

Absolute force of gunpowder cannot be determined.

It has been found by experiments that in calculating the initial velocity of a projectile, one third of the whole force was lost with a windage of $\frac{1}{10}$ th inch with a shot of $1 \cdot 96$ -in. and $1 \cdot 86$ -in. in diameter. The bore of the gun being $2 \cdot 02$ -in.

Loss of velocity by windage.

By ignition we understand the art of setting fire to a single grain, or to a charge of gunpowder, and by combustion we mean the entire consumption of a grain or of a charge.

Definition of ignition and combustion.

Upon the quickness of combustion mainly depends the applicability of gunpowder for Military purposes.

Quickness of combustion.

Gunpowder may be inflamed in a variety of ways, but whatever be the method, one portion of the substance must in the first instance be raised to a temperature a little above that necessary to sublime the sulphur, which can be removed from the other ingredients, by gradually raising the compound to a heat sufficient to drive it off in a state of vapour. The heat required for this purpose is between 600° and 680° Fahrenheit.

Ignition by heat.

When a charge of powder is exploded in the bore of a gun, to all appearance there would seem to be an instantaneous generation of the whole force. But in fact it is not so, a certain time being necessary to the complete combustion of the substance. This gradual firing is of the utmost importance, for were it otherwise, the gun, unless of enormous strength, must be shattered in pieces, as well as the projectile; for in such a case, this great force being suddenly exerted upon one part only of the material, there would not be time for the action to be distributed over the particles, at any great distance, before those in the immediate vicinity of the explosion, were forced out of the sphere of action of the cohesive force, and consequently rupture must take place.

Progressive combustion.

The effect of such an action may be observed by exploding detonating powders, in which are contained chlorate of potash or fulminating mercury. The action of that peculiar substance the chlorite of nitrogen is still more remarkable. There is also another compound, containing three parts of saltpetre, one part of carbonate of potash and one part of sulphur, which when brought to a certain heat will explode with great violence, its destructive force being very considerable; and this is principally due to the rapidity of the evolution of the gas, for its amount is less than that produced from gunpowder, but the complete decomposition occurs in a much shorter time.

Substances which have a more violent action than powder.

If gunpowder be in a damp state, the velocity of combustion will be less than when dry, and also a longer time will be necessary to ignite it, since the moisture

In a damp state less quickly fired, and why.

upon its conversion into vapour, absorbs a certain amount of heat which remains latent, and of which the useful effects so far as igniting the powder is concerned, is entirely lost.

Ignition by percussion.

Gunpowder may be ignited by the percussion of copper against copper, copper against iron, lead against lead, and even with lead against wood, when the shock is very great. It is more difficult to ignite gunpowder between copper and bronze,* or bronze and wood than between the other substances. Again, out of ten samples which were wrapt in paper and struck upon an anvil with a heavy hammer, seven of grained powder exploded and nine of mealed.

Influence of shape of grain on ignition.

If the part to which the heat is applied be of an angular shape, the inflammation will take place quicker than if it be of a round or flat form, on account of the greater surface that is exposed to the increased temperature.

The form of the grain influences the velocity of the transmission of flame.

If the grains are of a rounded form, there would be larger interstices, and a greater facility will be afforded to the passage of the heated gas, and therefore this shape is most favourable to the rapid and complete inflammation of each grain in the whole charge. On the other hand, particles of an angular or flat form, fitting into each other as it were, offer greater obstruction to this motion, and the velocity of the transmission of inflammation is thereby diminished.

Effect of size on the velocity of transmission of inflammation.

If the grains be small, the interstices will be small also, and the facility to the expansion of the gas thereby diminished. In the experiments with trains of powder, the increased surface exposed to the heated gas was found to more than compensate for the diminished facility to its expansion, and generally a train of small-grained powder laid upon a surface without being enclosed, will be consumed more quickly than a train of large-grained powder.

Large grain best suited for heavy ordnance.

But this is not the case in a piece of ordnance, a circumstance which amongst others will account for the diminished initial velocity given to the shot by a charge of small-grained musket powder, below that produced by the large-grained usually adopted for this service.

Velocity of the transmission of inflammation of the charge.

When a number of grains of powder are placed together as in the charge of a gun, and a few of them are ignited at one end of the cartridge, a certain quantity of gas is developed of a temperature sufficiently high to ignite those in their immediate vicinity. This has also such elasticity as to enable it to expand itself with considerable velocity. Again, the grains which are so ignited continue the inflammation to others in the same manner. The absolute velocity of expansion of this gas is very considerable; but the grains of gunpowder in the charge offer an obstruction to this motion, the gas having to wind its way through the interstices, and consequently the velocity is considerable diminished, but it is quite clear that it must be very much greater than the velocity of combustion. Mr. Robert estimates the velocity of transmission of inflammation of a charge in a gun at about 38 feet per second, and in all probability even this is much under the mark.

Estimate of Mr. Robert.

* Bronze consists of 78 parts copper to 20 of tin. Bell metal—78 copper and 22 tin. Gun metal—100 copper to 8 to 10 tin. Brass—2 copper, 1 zinc and calamine stone, to harden and colour.

Many experiments have been made by observing the velocity of transmission of inflammation of trains of powder under various circumstances, but they do not show us what would be the velocity in a confined charge. The velocity increased with the section of the train, and further when at the end first lighted, there was an obstruction to the escape of gas, as in the case of a gun, a much shorter time was required for complete inflammation.

Experiments made on this subject.

When the charge of powder in a gun is ignited the grains being enveloped by the heated gas, we may consider that each grain is ignited over its whole surface at once. If the grains of powder were of equal or regular form, the time each would be consuming, might be easily calculated, but since in ordinary cases they are irregular in form, although the grains may be of the same weight, the time necessary for their complete decomposition will be very different.

Time of decomposition depends upon form of grain.

The quickness of combustion will depend upon the dryness of the powder, the density of the composition, the proportion of the ingredients, the mode of manufacture, and the quality of the ingredients.

Circumstances affecting combustion.

Were a cubical grain to be ignited upon its whole surface, the decomposition may be supposed to take place gradually from the surface to the centre, and the original cubical form to remain until the whole is consumed, the cube becoming smaller and smaller. If, then, the rate of burning be the same throughout, the quantity of gas generated in the first half portion of the time will evidently be considerably more than in the latter half, as in the latter case there will be a much lesser surface under the influence of flame.

Combustion of cubical grains considered.

If the form of the grain be elongated, then will the quantity of gas generated in a given time from a grain of similar weight to that of the cube or sphere, be increased, on account of the greater ignited surface, and consequently the time necessary for its combustion will be diminished. If it be of a cylindrical form for example, this time must be reckoned from the diameter of the cylinder, its length not influencing it in the least, although as we have seen, it enters into the consideration of the quantity of the gas generated in a given time.

Elongated and cylindrical grains.

In the ordinary large-grain powder, the majority of the grains are of the elongated or flat form, from whence considerable advantage is derived, particularly in short guns, since it causes the greatest portion of the charge to be decomposed before the projectile is moved sensibly from its original position.

Large grain.

If the charge be composed of mealed powder a longer time is found to be necessary for the complete combustion of the whole than in the case where the substance is granulated, and the initial velocity of a shot is reduced about one third by employing the substance in that state.

Mealed powder.

A piece of pressed cake weighing 1.06oz., was put into a mortar, and a globe of some light substance, placed upon it, and the powder being consumed after ignition without ejecting the ball from the bore of the piece. When an equal quantity was divided into seven or eight pieces, the globe was thrown out of the mortar; breaking the cake into twelve pieces; the ball ranged 3.3 yards; being further increased to fifty grains, it ranged 10.77 yards; and when the ordinary powder was used, the ball was projected 56.86 yards.

The effect of granulating gunpowder.

Action depends upon size and form of grain.

It will appear from the above remarks, that the force generated from the charge of powder in a gun, will be greatly influenced by the size and form of the grains composing it.

Density of gunpowder.

In order to obtain a gunpowder which shall possess a proper amount of force, it is necessary that the ingredients should be thoroughly incorporated, and the process of incorporation will in great measure affect the density of the grains. After going through the process, it is subjected to a certain pressure, in order that the substance in travelling may not be reduced to a fine powder, which would cause the velocity of transmission of inflammation to be diminished. But there is a certain point beyond which it would not be advantageous to increase the density, and this seems to vary with the size of the grain. With large-grain powder the action in a musket, or in guns with small charges, is greatest with a low density; while with very small grain, the highest velocities are obtained generally with the gunpowder of great density; but in heavy guns with ordinary charges, the large-grained powder should be of considerable density in order to obtain the greatest effect, though still it must not be too great.

Advantages of glazing.

The principal advantages of glazing are; first, that the powder so prepared, will in travelling, owing to the smaller amount of destructive force consequent on friction, produce less mealed powder; and secondly, that in a damp country like England, the glazing imparts a preserving power to the powder, as the polished surface is less likely to imbibe moisture than the rough.

Disadvantages of glazing.

The disadvantages of glazing consists in its polishing the surface, and thus depriving it of those angular projections which cause the ignition and combustion to be carried on with greater rapidity, by rendering the interstices smaller, the consequence of which is, that there is not so much gas produced previously to the projectile leaving the gun, and in large charges a portion will be blown out unfired. There must be a limit then to glazing, which it would not be proper to exceed. At an experiment with glazed and unglazed powder, the ranges on the eprouvette were 75 for glazed, and 98 for unglazed. This loss of power, consequent on glazing, has caused it to be done away with in France and Russia. With fine grain powder it is not of so much consequence, as it is, to a certain degree, corrected by the size of the grain.

Experiments as to glazing.

Glazing less hurtful to fine grains.

Size of grain determined by size of charge.

The rapidity with which a charge of gunpowder is consumed will depend not only in a certain degree upon the size of the grain, but on the manner in which the charge is put together, for if a charge is closely pressed, the gases meeting resistance in their endeavours to escape between the interstices, will not propagate the ignition so rapidly. With large charges, there exists a positive advantage for the grains to be rather large, so that the most distant parts of the charge should be reached by the gases as quickly as possible; whilst with that of a rifle, the charge being small, the fineness of the grain does not interfere with the quantity of the gas developed. Whence it may rationally be concluded that the dimensions of the grains should increase in proportion to the quantity of the charges into which they are to enter, that is to say, in proportion to the interstices. Ramming down a charge tightly must therefore interfere with the velocity of combustion.

Tight ramming bad.

FOULING.

The produce obtained by the decomposition of gunpowder are the gaseous and the solid. The gaseous is chiefly nitrogen and carbonic acid. The solid is sulphur and potassium, mixed with a little charcoal, but the solid produce is nearly entirely volatilized at the moment of explosion through the high temperature.

Produce of
decomposed
gunpowder.

Fouling is occasioned by the deposition inside the barrel of the solid residue proceeding from the combustion of the powder.

Fouling.

One of the principal of these, namely, the sulphurate of Potassia, is deliquescent, or attracts water from the atmosphere. Hence, on a clear day, when the air holds little moisture, the fouling does not attain that semi-fluid state it so speedily attains in a damp day, and it is not so easily removed, and tends to accumulate inside the barrel. Fouling may also be increased or diminished, according to the quality of the powder.

Conditions of
fouling de-
pend on state
of atmosphere

Fouling occasions loss of power from the increased friction, and causes inaccuracy in direction and elevation, by filling the grooves, and thus preventing the proper spiral motion being imparted to the projectile.

Effects of
Fouling.

EFFECTS OF GUNPOWDER ON METALS.

The effect produced by Gunpowder on metals, in long continued and rapid firing, is very extraordinary. Several of the guns employed at the siege of San Sebastian were cut open, and the interior of some of the vent holes, which were originally cylindrical, and only two-tenths of an inch in diameter, were enlarged in a curious and irregular manner, from three to five inches in one direction, and from two to three inches in another, but the brass guns were much more affected than the iron. In December, 1855, there were lying in the arsenal at Woolwich several of the heaviest sea mortars, which had recently been used at the bombardment of Sweaborg, and the continuous firing on that occasion had split them into two nearly equal portions from muzzle to breech, a trunnion being with each half.

Difference of
effect on brass
and iron guns.

Heavy guns for garrisons, sieges, &c., are made of cast iron; guns for field purposes, where lightness is required, are made of gun metal.

These guns are generally denominated brass guns. They can be loaded, properly pointed at an object, and fired about four times in three minutes, but they will not stand long continued rapid firing, or more than 120 rounds a day, as the metal, when heated, softens, and the shot then injures the bore. Heavy iron guns may be loaded, fired, &c., once in two minutes. They suffer more from the total number of rounds that have been fired from them, without reference to the intervals between each round, than from the rapidity of the firing. Four hundred and five hundred rounds per day have not rendered an iron gun unserviceable.

Difference of
effect of brass
and iron guns

MISCELLANEOUS EXPERIMENTS.

The following experiments, extracted from Mr. Wilkinson's "Engines of War," serve to illustrate the capability of metals to resist the force of gunpowder, and may be of some practical utility, as well as prove interesting merely as matter of curiosity.

Experiment 1.—A piece about 5 inches long was cut off the breech-end of a common musket barrel. It was screwed at the part cut, and another plug fitted, so as to have two plugs, one at each end, leaving an internal space of about 3 inches. A percussion nipple was screwed into the end of one of these plugs. This being arranged, one of the plugs was turned out, and one drachm of gunpowder introduced. The plug was replaced, and the powder fired by putting a copper cap on the nipple, and striking it with a hammer. The whole force of the powder escaped at the hole in the nipple. Two, three, four, five, and six drachms were successively introduced, and fired in the same manner, without bursting or injuring the piece of barrel. At last, seven drachms forced out one end, in consequence of the screw having been carelessly fitted. This defect being repaired, Mr. Marsh, of Woolwich, repeatedly fired it with five drachms, merely holding it with a towel in his left hand, and firing it with a blow of a hammer. Six drachms of powder is the full service charge for a flint musket, and four drachms of a percussion musket; yet this immense pressure can be resisted by a cylinder of iron not more than one quarter of an inch thick, and not iron of the best quality.

Experiment 2.—A good musket barrel had a cylinder of brass, three inches long, turned to fit the muzzle, and soldered in, so as to close it air-tight. The plug, or breech-screw, was removed, and a felt wad was pushed in with a short piece of wood, marked to the exact depth the charge would occupy, to prevent the ball rolling forward. A musket ball was then dropped in, and a cartridge, containing three drachms of powder, was introduced. The breech being screwed in, left the barrel loaded. It was fired by a percussion tube, but there was no report. On removing the breech-screw, the ball was found to be flattened. A repetition of this experiment, with four drachms, produced a similar result, but the ball was rather more flattened. With five drachms, the ball was perfectly round and uninjured. Six drachms burst the barrel close under the bayonet stud; the ball escaped through the opening, disfigured, but fell close to the barrel. In these experiments the barrel always advanced, instead of recoiling, as usual.

Experiment 3.—Made at Woolwich Arsenal, with a Gomer mortar, which is a mortar bored conically, so that the shell, when dropped in, fits closely all round, instead of being bored cylindrically, with a chamber in the centre. The mortar being laid at an angle of 45° , one drachm of powder was put into the bottom, and a 68-pounder iron shot over it. When fired, the ball was projected two feet clear of the mortar. A wooden ball, precisely the same diameter, but weighing only 5lbs., was scarcely moved by the same charge, and with two drachms of powder it was just

lifted in the mortar, and fell into its place again. Here we find a weight of 68lbs. thrown to the distance of two feet by the same power which would not lift 5lbs., and the wooden ball scarcely moved by double the powder.

This proves that the firing of gunpowder under such circumstances is not instantaneous. In the first instance, the small quantity of powder had a large space to fill below the ball, and a heavy weight to move; therefore, could not stir it at all until the whole was ignited, when the force was sufficient to throw it forward two feet. In the second case, the first portion of gas that was generated by ignition of the powder, was sufficient to lift the lighter weight, just enough to allow all the force to escape round it before it had time to accumulate.

Experiment 4.—A cannon ball, weighing 24lbs., was placed exactly over the vent-hole of a loaded 32-pounder cannon, which was fired by a train of gunpowder, when the rush from the vent projected the 24-pounder ball to a very considerable height in the air, although the diameter of the hole was only two-tenths of an inch.

Experiment 5.—A most ingenious method of ascertaining the relative quickness of ignition of different qualities of gunpowder.

A gun-barrel mounted on a carriage with wheels, and moving on a perfectly horizontal railway, is placed at right angles to another short railway, at any convenient distance (suppose fifty feet, or yards); on the second railway a light carriage moves freely with any desired velocity, being drawn forward by means of a weight and pulleys: a cord is attached to the front of this carriage, which passes over a pulley at the end of the railroad, and is continued up a high pole or staff over another pulley at the top, at which end the weight is attached. A long rectangular frame covered with paper is fixed perpendicularly on the carriage, so that when it moves forward it passes across the direct line of the barrel, and forms a long target. A percussion lock is attached to the barrel, which is fired by a detent, or hair-trigger, and the wire which pulls it is disengaged at the same instant to admit of recoil. This wire is carried straight on to the target railroad, and fixed to a small lever, against which the front part of the target-carriage strikes as it is carried onwards by the weight. This constitutes the whole apparatus. When required to be used, the barrel is loaded with gunpowder accurately weighed, and a brass ball that fits the bore correctly: the weight is then disengaged, and the target moves quickly along, discharging the barrel as it passes, and the ball goes through it. With the same powder tried at the same time, the ball constantly goes through the same hole, or breaks into it. If the next powder tried be slower of ignition than the preceding, the ball will pass through another part of the target more in the rear; if quicker, more in advance; thus affording a means of ascertaining this important quality of gunpowder with considerable accuracy: the velocity of the target-carriage can be easily regulated by increasing or diminishing the weight which draws it forward. The differences in the distances between which the balls strike the target with different kinds of powder was frequently as much as ten or twelve inches; but it is not an apparatus commonly used, having been merely constructed for experimental purposes.

ON THE TIME REQUIRED FOR IGNITION OF GUNPOWDER.

Gunpowder like all other inflammable substances requires to be raised to a certain temperature, before it will ignite, viz., to a dull red heat, or about 600° Fahrenheit. If the heat passes with such rapidity through the powder, so as not to raise the temperature to the necessary degree, then the powder will not ignite, from the velocity of transit, so that it might be possible to calculate theoretically, the velocity that must be given to a red hot ball to enable it to pass through a barrel of gunpowder without causing explosion. The passage of electric fluid through gunpowder may be adduced in evidence of the ignition being dependent on the degree of velocity. The flame of all fulminating powders will pass through the centre of a box filled with gunpowder without igniting one grain of it. If a train of gunpowder be crossed at right angles by a train of fulminating mercury, laid on a sheet of paper or a table, and the powder be lighted with a red hot iron wire, the flame will run on until it meets the cross train of fulminating mercury, when the inflammation of the latter will be so instantaneous as to cut off all connection with the continuous train of powder, leaving the remaining portion of the gunpowder unignited. If on the contrary the fulminating powder be lighted first, it will go straight on and pass through the train of gunpowder so rapidly, as not to inflame it at all. Were a gun to be charged with gun-cotton and gunpowder, the latter would be fired out unignited.

EFFECTS OF ACCIDENTAL EXPLOSIONS OF GUNPOWDER.

Considering the combustible nature of the materials, accidents very seldom occur; when they do, it is more frequently in the process at the Mill while under the runners.

On one occasion at Waltham Abbey Mills, when the powder exploded, after having been two hours under the runners, the doors and windows of the Mills on the opposite side of the stream, were forced open outwards, and the nails drawn. A similar effect took place when the Dartford Mills blew up, January 1833, in consequence of an accident in the packing house. A window which had been recently fitted up in Dartford Town, about a mile and a half distant from the works, was blown outwards into the street, and a considerable quantity of paper was carried as far as Eltham and Lewisham, distances of eight and ten miles. The sudden rarification of the air may account for this circumstance, the atmospheric pressure being removed in the vicinity of the doors and windows, they were forced open outwards by the expansive force of the air contained within the buildings.

ON ANCIENT ENGINES OF WAR.

The Utopian may shrink from the contemplation of so painful a subject as War, the Moralist may raise his voice against the justice of it, but the practical philosopher can see very little chance of its cessation, and actuated with the very best intentions, will endeavour to render War as terrible as possible, well knowing, that as soon as certain death awaits two rival armies, princes must fight their own battles, or war must cease.

War a painful topic.

Advantages of war being destructive.

Man's first rude attempts at missile weapons were doubtless limited to throwing sticks and stones by the mere aid of his hands; acts in which the monkey, the bear, and even the seal are very successful emulators. A desire of more successful aggression, together with increased facilities for the destruction of game and wild animals, doubtless soon suggested to man the use of projectiles more efficient than these. By a very slight change of form, the simple stick would become a javelin, capable of being hurled with great force and precision. An aid would suggest itself for casting a stone, by means of a fillet or band, subsequently called a sling, and next would be invented the bow, which, in process of time by subsequent additions would become the arbalest or cross-bow.

First missile weapons, sticks and stones.

Javelin.

Sling.

Bow.

Arbalest.

It appears that axes have been used as *projectiles*: for Procopius, describing the expedition of the Franks into Italy, in the sixth century, tells us:—Among the hundred thousand men that King Theodobert I. led into Italy, there were but few horsemen. The cavalry carried spears. The infantry had neither bow nor spear, all their arms being a sword, an axe, and a shield. The blade of the axe was large, its handle of wood, and very short. They *hurl* their axes against the shields of the enemy, which by this means are broken; and then, springing on the foe, they complete his destruction with the sword.

Axes used as projectiles.

A hatchet or tomahawk is used as a projectile weapon by the North American Indians. The difficulty of throwing such a weapon with effect, would of course consist in causing the edge to strike the object aimed at. Now, such a hatchet as they usually make use of, if thrown by its handle, will revolve in a perpendicular plane about once in every three yards, irrespective of the force with which it moves. An Indian judges his enemy to be distant from him any multiple of 3 yards as 15, 18, 21, and strikes him full with the edge of his weapon accordingly.

Tomahawk used as a projectile.

A circular disk or quoit is in use in India amongst the Sikhs, particularly that sect of them called Akali, as a weapon, and in their warlike exercises; the species

"Chuckur" or disk used as a projectile.

used in war have a triangular section, those thrown for amusement are flat with a sharp edge. A skilful man will throw one of these chuckers or quoits to a distance of a hundred and thirty yards, or more, with very considerable accuracy, the quoit being at no period of its flight above six feet from the ground. The sharpness of edge, combined with the rotatory motion of these quoits, and the difficulty of avoiding them, renders them formidable weapons in skilled hands. The Akali wear them on their turbans, of several different sizes and weights; a small one is often worn as a bracelet on the arm. Many of these fanatics took part in the last Sikh war, and severe wounds made with these weapons were by no means uncommon.

Armour and
fortifications.

By the time portable weapons would have been brought to some degree of perfection, man's increasing sciences and civilization would have led him to make armour, to build cities, and enclose them with walls. Now would arise the necessity for other projectiles of greater force, inasmuch as in the event of war, the armour should be penetrated, and walls, &c., would have to be demolished.

Improved
projectiles.
Change to
heavy projec-
tiles.

Catapulta.
Balistæ.
Sling princi-
ples.

Projectiles
used with
Catapulta.

The transition from portable projectiles to those of a heavier class was obvious enough. Enormous javelins and darts were hurled by cross-bows of corresponding size, termed Catapultæ, (plate x.), and stones, &c., were thrown by Balistæ (plate ix. and xii); and secondly, instruments formed on the principle of the sling.

These machines threw not only large darts and stones, but also the bodies of men and horses. Athenæus speaks of a Catapulta which was only one foot long, and threw an arrow to the distance of half a mile. Other engines, it is said, could throw javelins from one side of the Danube to the other. Balistæ threw great beams of wood, lances twelve cubits long, and stones that weighed three hundred pounds.

Millstones,
&c., used in
England.

Our forefathers used to cast forth mill-stones. Holinshead relates that when Edward I. besieged Stively Castle, he caused certain engines to be made, which shot off stones of two or three hundred weight.

B. C. 1451.

B. C. 809.

First mention
of Artillery.

The first intimation of trees being cut down "to build bulwarks against the city till it be subdued," occurs in Deut. xx., 19, 20, but the earliest precise mention of Artillery is in 2nd Chron., xxvi, 15, where we are told that Uzziah "made in Jerusalem engines invented by cunning men, to be upon the towers and upon the bulwarks, to shoot arrows and great stones withal;" and Josephus relates that Uzziah "made many engines of war for besieging cities, such as hurl stones and darts with grapplers, and other instruments of that sort." He must therefore be considered the inventor of them, and from that time they began to be employed in attacking and defending towns.

Balistæ at Re-
gium, B.C. 388
At Motya
B.C. 370.

The earliest instances of projectile machines in profane history appear to be at the siege of Regium and Motya by Dionysius, where, having battered the walls with his rams, he advanced towards them towers rolled on wheels, from whence he galled the besieged with continual volleys of stones and arrows, thrown from his Balistæ and Catapultæ.

At Rhodes
B.C. 303.

The next memorable instance is the siege of Rhodes by Demetrius Polyreetes, who brought forward a newly invented machine, called Helepolis, (taker of Cities), with a variety of other engines, and employed 30,000 men in the management of them:

Tacitus mentions an extraordinary engine, used by the 15th Legion at the battle of Cremona, against the troops of Vespasian. It was a Balista of enormous size, which discharged stones of weight sufficient to crush whole ranks at once. Inevitable ruin would have been the consequence, had not two soldiers, undiscovered, cut the ropes and springs. At length, after a vigorous assault from Antonius, the Vittelians, unable to resist the shock, rolled down the engine, and crushed numbers of their assailants, but the machine, in falling, drew after it a neighbouring tower, the parapet, and part of the wall, which afforded the besiegers easier access to the city.

Balistæ at
Cremona.

Josephus relates that at the siege of Jotapata, "a stone from one of the Roman engines carried the head of a soldier, who was standing by him, three furlongs off;" that "lances were thrown with great noise, and stones, weighing 114lbs. troy, together with fire and a multitude of arrows." The dead bodies of men and horses were also thrown at this siege, and at that of Jerusalem, A.D. 70, to inspire terror.

Balistæ at
siege of Jo-
tapata.

Dead men and
horses pro-
jected.

Form of Ba-
listæ.

The earliest form of Balistæ appears to have been a very long beam, suspended in a frame on a centre of motion, one end being considerably longer than the other. To the short end was attached a great weight, such as a chest filled with earth or stones. To the longer end a sling was affixed, in which, after being drawn down, a stone was placed, and on being suddenly let go, the long end flew up, and discharged the stone with great violence.

Catapultæ were sometimes constructed to discharge a flight of arrows at once, by placing them on a rack, and causing a strong plank, previously drawn back, to strike against their ends. The more perfect engines of the Romans were all dependent on the elasticity of twisted cords made of flax, hemp, the sinews or tendons of animals, from the neck of the bull, or legs of the deer species, and ropes formed of human hair were preferred to all others, as possessing greater strength and elasticity. Catapultæ were immensely powerful bows, drawn back by capstans, levers, or pulleys, having only a single cord for the arrow, (plate x.), but the Balistæ had a broad band, formed of several ropes to project the stone, which was placed in a kind of cradle, like a cross-bow. (plate ix.)

Form of Cata-
pultæ.

The Normans appear to have introduced a kind of Field-Artillery, consisting of instruments or machines, from which darts and stones were thrown to a considerable distance, as they occur at the battle of Hastings. They also employed arrows, headed with combustible matter, for firing towns and shipping.

Balistæ at
battle of
Hastings 1066

We read in the Scriptures of "Fiery Darts." Ephns. vi., 16.

Fiery darts,
A. D. 64.
Fire from Ba-
listæ.

Our ancestors derived the knowledge of some composition from the Saracens, which resembled Greek-fire, and was often thrown in pots from the Balistæ.

From a treatise on the "Art of Fighting," by Hassan Abrammah, we learn that the Arabs of the 13th century employed their incendiary compositions in four different ways. They cast them by hand; they fixed them to staves, with which they attacked their enemies; they poured forth fire through tubes; and they projected burning mixtures of various kinds by means of arrows, javelins, and the missiles of great engines.

Fire by Arabs
commence-
ment of 13th
century.

Bombs of
glass, &c.

Vessels of glass or pottery, discharged by hand or by machines, were so contrived, that on striking the object at which they were aimed, their contents spread around, and the fire, already communicated by a fusee, enveloped everything within its reach. A soldier, on whose head was broken a fire-mace, became suddenly soaked with a diabolic fluid, which covered him from head to foot with flame.

Fire-mace.

Bombs from
Balistæ.

Bombs were also thrown from Balistæ. An engine was constructed at Gibraltar, under the direction of General Melville, at the desire of Lord Heathfield, for the purpose of throwing stones just over the edge of the rock, in a place where the Spaniards used to resort, and where shells thrown from mortars could not injure or annoy them.

Onager.

Of machines formed on the sling principle, that called Onager (plates vii. and viii.) may be regarded as typical of all the rest. Its force entirely depended upon the torsion of a short thick rope, acting upon a lever which described an arc of a vertical circle. The lever had attached to its free extremity a sling, or sometimes it merely terminated in a spoon-shaped cavity. When bent back, it was secured by a catch or trigger, and charged with a stone. On starting the catch by a blow with a mallet, the lever described its arc of a circle with great velocity, and projected the stone to a considerable distance.

I shall now briefly describe some of the portable missive weapons which have been used by different nations.

Javelin.

The Javelin, or dart, variously modified, is known under several names. The ancients were well acquainted with it. In the Scriptures, we have frequent notice of it; and the ancients instituted javelin matches. It would appear that the javelin used on horseback was about five feet and a half long, and headed with steel, usually three-sided, but sometimes round. The Roman Cavalry, after the conquest of Greece, were armed much like the Infantry, carrying swords, shields, and javelins with points at both ends. Sometimes, in order to launch it with greater force, it was not propelled by the unaided arm, but by the assistance of a thong fastened to its butt end; and we are informed that the Greeks and Romans projected darts and javelins by the assistance of a sling or strap, girt round their middle.

Arms of the
early Romans

Aid to pro-
jection.

Djereed.

At the present time, a javelin, termed Djereed, is used with considerable effect by certain oriental nations, who invariably employ it on horseback. The Roman infantry possessed a weapon of the javelin kind, termed Pilum, every man of the legionary soldiers carrying two. The point of this weapon being very long and small, was usually so bent at the first discharge as to be rendered useless afterwards. With every improvement that the javelin was susceptible of, it never could acquire a long range; hence we find, that as Archery became developed, the use of the weapon declined. Amongst savage nations, the use of the javelin is very common, but the inhabitants of Australia have a manner of throwing it altogether peculiar to themselves, not throwing it while poised at the balance, but projecting it by means of a stick applied at the butt end. This contrivance accomplishes a great increase of range, but does not contribute to accuracy of direction. At short distances, the penetrating force of the javelin is considerable, as is learned from the act of harpooning a whale, a harpoon being merely a javelin.

Pilum.

Australian
mode.

Harpoon.

THE SLING.

Means by which stones would be thrown by greater force than the hand, would naturally be resorted to; accordingly we find the sling ranks amongst the first of ancient offensive weapons. Numerous examples are mentioned in Scripture, as in Judges xx., 16, "Among all this people, there were seven hundred chosen men left-handed; every one could sling stones at a hair breadth and not miss;" and also that of David and Goliath, &c.

At the siege of Troy, the masses were organized into two kinds of infantry: one light and irregular, carrying horn bows, short darts, and slings; the other regular and heavy, armed with spears. At the battle of the Granicus, B. C. 334, Alexander the Great had in his army light infantry, consisting of slingers, bow-men, and javelin-men. The Carthagenians had slingers in their pay before the first Punic War.

The Sling was very common in Greece, and used by the light armed soldiers. Arrows, stones, and leaden plummets, were thrown from them, some of which weighed no less than an Attic pound. Seneca reports that its motion was so vehement that the leaden plummets were frequently melted!!! The Romans had slingers in their armies, for the most part inhabitants of the Islands of Majorca, Minorca and Ivica.

Pliny ascribes the invention of slings to the Phœnicians, but Vegetius to the inhabitants of the Balearic Islands, who were famous in antiquity for using them. It is said, those people bore three kinds of slings, some longer and others shorter, to be used as their enemies were nearer or more remote; the first served them for a head band, the second for a girdle, and the third they always carried in their hands. In fight they threw large stones with such violence, that they seemed to be projected from some machine, and with such exactness, as rarely to miss their aim; being constantly exercised from their infancy, their mothers not allowing them to have any food, until they struck it down from the top of a pole with stones thrown from their slings.

The Latin for our English word *fundus*, which originally signifies a "stone's-throw of land," or as much land as could be included within the range of a stone thrown from a sling. The materials of which slings were composed, were either flax, hair or leather, woven into bands or cut into thongs, broad in the centre to receive the load, and tapering off to the extremities. Slings have been made with three strings, with a cup let into the leather to hold the bullet or stone, and were called "Fronde à culôt." In plate xiii, fig. 3, there is a representation of a slinger of the early part of the thirteenth century, whose weapon differs from that of the Anglo-Saxon or common sling, in having a cup for the reception of the projectile. Slings were sometimes attached to sticks to increase their power, as, besides the ancient cord sling, there appears in the manuscripts of the thirteenth century a variety of this arm; the "Staff Sling." (plate xiii, fig. 2.) It seems to have been in vogue for naval warfare, or in the conflicts of siege operations.

The slings projected their missiles with such force that no armour could resist their stroke. Slings never appear to have been much used by the English, although

Slings mentioned in Judges. B.C. 1406.

Slings used B. C. 1406.

Siege of Troy between 800 and 900 B. C. 1134

Battle of the Granicus B. C. 334.

First Punic war 241 to 263 B. C. Slings common in Greece

Slingers in Roman armies

Invention ascribed to Phœnicians and also to inhabitants of Balearic islands.

Materials of slings.

Slings with cup.

Staff-sling.

Force of slings

Used for the
English, A.D.
1342.

Bullets out of
slings.

Slings at the
siege of Saucere,
1572.

Range.

Slings last
used, 1814.

Froissart mentions an instance of their having been used for them by the people of Brittany, in a battle fought in that province during the reign of Philip de Valois, between the troops of Walter de Manin, an English knight, and Louis d'Espagne, who commanded six thousand men on behalf of Charles de Blois, then competitor with the Earl of Montford for the Duchy of Brittany. Froissart says, that what made Louis lose the battle was, that during the engagement the country people came unexpectedly and assaulted his army with *bullets* and slings.

According to the same author, slings were used in naval combats, when stones were also sometimes thrown by hand. * Slings were used in 1572, at the siege of Saucere by the Huguenots, in order to save their powder. They were also used by the people of Brittany to such an extent against the Roman Catholic party, that the war was called "Guerre de Fronde." With respect to the range of this projectile, it is said, that a good slinger could project a stone 600 yards. This seems doubtful. The most recent instance of slings being used in war, occurs in "Straith on Fortification," page 121, and which contains an extract from the siege journal of Serjeant St. Jacques of the French Corps de Genie, who was most successfully employed with a small French garrison in the defence of the Castles of Monzowin, Arragon, against the Spaniards, 1814.

THE BOW.

The bow
almost
universal.

This weapon under some shape or other was employed by most nations of antiquity, but not always as a warlike instrument. Scarcely any two nations made their bows exactly alike. The Scythian bow we are told, was very much curved, as are the Turkish, Persian, and Chinese bows (plate iv. figs. 1 & 2) at the present day, whilst the celebrated weapon of our ancestors when unstrung was nearly straight.

It is now used among those savage tribes of Africa and America, to which fire-arms have not yet reached.

Bows in
Scripture.

Bows B.C.
1892.

B.C. 1760.

We frequently read of the bow in Scripture, and the first passage in which the use of the bow is inferred, is in Gen. xxi. 20, where it is said of Ishmael, "And God was with the lad, and he grew, and dwelt in the wilderness and became an archer." But in the 16th verse it is said that Hagar his mother, "sat her down over against him, a good way off, as it were a *bow shot*; for she said let me not see the death of the child":—this verse implies an earlier practice with the bow than can be adduced by any profane historian. In Gen. xxvii. 3, Isaac directs his son Esau: "Now therefore take I pray thee thy weapons, thy quiver and thy bow, and go out to the field, and take me some venison; and make me savory meat, such as I love, and bring it to me that I may eat, and that my soul may bless thee before I die." The overthrow of Saul was particularly owing to the Philistine archers; and "David

* It is stated by Sir Robert Wilson that at the battle of Alexandria the French and English threw stones at each other, during a temporary want of ammunition, with such effect that a Serjeant of the 28th Regiment was killed, and several of the men were wounded. Stones were thrown by the English Guards at the battle of Inkerman.

"bade them teach the children of Judah the use of the bow." The companies that came to David at Ziklag were armed with bows, and "could use the right hand and the left in hurling stones and shooting arrows." (I. Chron. xii. 2.) The bow is of very high antiquity among the Greeks, whose bows were usually made of wood, but sometimes of horn, and frequently in either case beautifully ornamented with gold and silver; the string generally made of twisted hair, but sometimes of hide. The ancient Persians drew the strings towards their ears, as is the practice still with the English. The ancient Greeks, however, drew the bowstring towards their breast, and represented the fabled Amazons as doing the same, and hence the tradition of these people cutting off their right breasts, in order to give facility for drawing the bow. Until the second Punic war, the Romans had no archers in their armies, except those who came with their auxiliary forces. Subsequently they became more employed, although as far as we can learn, not by native troops, but by Orientals in their pay.

B.C. 1058.

Manner of drawing the bow.

First used by Romans.

The early Britons had merely bows and arrows of reed, with flint or bone heads. Arrows were used by the Welch in Norman reigns, who were famous archers; their bows were made of wild elm, but stout, and not calculated to shoot a great distance, but their arrows would inflict very severe wounds in close fight. Their arrows would pierce oaken boards four inches thick. The bow was also a weapon of war among the Anglo-Saxons. The Salic law shows that both the sling and the bow were used by the contemporary Franks; and they even used poisoned arrows. The Anglo-Saxon bow was of the form of the Grecian, but it was only under the Normans that the bow became a master weapon; the Saxons principally using it, like the people of Tahiti of the present day, for killing birds.

Bows of Britons.

Bows of Welsh.

Bows of Anglo-Saxons

During the reign of Clovis, the French made no use of the bow in their armies, but it was employed during the reign of Charlemagne, who flourished in the end of the eighth century; as a Count is mentioned, who was directed on conducting soldiers to the army, to see they had their proper arms; that is a lance, a buckler, a bow, two strings, and twelve arrows.

No bows in France A.D. 514.

William the Conqueror was a skilful archer, and the battle of Hastings was decided by the bow, and we hear that Harold was shot with an arrow. Although the Anglo-Saxons and Danes were well acquainted with the bow from the earliest period, it appears to have been only employed for obtaining food, or for pastime, and we are perhaps indebted to the Norman Conquest for its introduction as a military weapon. The Normans at the battle of Hastings are said to have used the arbalest or cross-bow as well as the long bow. Ever after this, the bow became a favourite weapon. During the reign of Henry II., archery was much cultivated, and great numbers of bowmen were constantly brought into the field; and to encourage its practice, a law was passed, which freed from the charge of murder any one who in practising with arrows or darts, should kill a person standing near. This appears to be the first regulation to be found in our annals, and was probably founded on the old law of Rome. The English conquests in Ireland during the reign of Henry II. were principally owing to the use of the long bow in battle, which the Irish wanted. The Invasion of Ireland was headed by Richard de Clare, Earl of Pem-

A.D. 1066.

Harold shot with an arrow

Known by Danes and Saxons.

As a military weapon at the battle of Hastings.

Archery encouraged by statute.

Long bow in conquest of Ireland 1172.

broke, surnamed "Strong-bow." His force was numerically very small, consisting chiefly of archers, and it is stated that such was the advantage their superior arms and military skill gave the invaders, that 10 knights and 70 archers defeated a body of 3000 Irish opposed to them, on their landing near Waterford.

A.D. 1199. The exact time when shooting with the long-bow began in England is unsettled, our chroniclers do not mention archery till the death of Richard I.

During the reign of Henry III. there were among the English infantry, slingers, archers, and cross-bow men.

Cressy 1346. It seems that the long-bow was at its zenith in the reign of Edward III., who appears to have taken great pains to increase its efficacy, and to extend its use. The terrible execution effected by the English archers at Cressy, and at Poitiers ten years after, was occasioned by British archers.

Homelden 1403. The decisive victory over the Scots at Homelden was entirely achieved by them, and the Earl of Douglas found the English arrows were so swift and strong, that no armour could repel them; though his own was of the most perfect temper, he was wounded in five places. The English men-at-arms, knights and squires, never drew sword or couched lance, the whole affair being decided by the archers.

Shrewsbury 1403. They again did terrible execution at the battle of Shrewsbury, in 1403, where Hotspur was slain, and the battle of Agincourt was their undivided conquest.

Agincourt 1415. During the reign of Henry VI., the Parliament voted an army of 20,000 bow-men for service in France. The battle of St. Albans, 1455, seems to have been entirely won by the archers. Although fire-arms had attained no inconsiderable degree of perfection in the reign of Henry VIII., yet the long-bow was still the favourite weapon. Indeed, in the reign of Elizabeth, the musket was so unwieldy, and slow to charge and discharge, that the bow was considered superior by many.

20,000 bow-men 1455. We find that Queen Elizabeth, 1572, engaged to furnish Charles IX. of France with 6,000 men, part to be armed with long, and part with cross-bows; and in the attack made by the English on the Isle of Ré, 1627, it is said some cross-bow-men were in the army. In 1643 a company of archers was raised for the service of Charles I.; and in a pamphlet printed in 1664, there is an account of the successes of the Marquis of Montrose against the Scots; and bow-men are repeatedly mentioned as in the battle. The Grenadiers of the Highland Regiments, in the time of William III., when recruiting, wore the old red bonnet, and carried bows and arrows with them.

The Highland bow was very short, and by no means powerful.

MERITS OF THE LONG BOW.

Range of long-bow. The English could not accomplish more than 600 yards, except on a few extraordinary occasions; our modern archers not more than from 300 to 500 yards. The Turkish ambassador when in England in 1795, sent an arrow upwards of 480 yards; and there are two or three instances on record since archery has been merely a pastime, which have exceeded it by twenty or thirty yards. It is said of Domitian, that he would cause one of his slaves to stand at a great distance with his hands

Accuracy of long-bow.

spread as a mark, and would shoot his arrows so correctly as to drive them between his fingers. Commodus, with an arrow headed with a semi-circular cutting edge, could cut or sever the neck of a bird. The story of William Tell, who struck an apple placed upon his child's head, is well known, and generally regarded in the light of an historical fact. It is stated that Robin Hood could split a hazel wand.

In a journal of Edward VI., His Majesty relates that 100 archers of his guard shot before him two arrows each, and afterwards altogether. The object aimed at was a well-seasoned deal board, one inch thick. Many pierced it quite through, and some struck in a board on the other side. The distance is not mentioned, but we know that Henry VIII. prohibited any one above the age of 25 to shoot at a mark at a less distance than 200 yards.

Penetration
of long-bow

The long-bow was light, inexpensive, and unaffected by weather, as the strings could be removed. Moreover, 12 arrows could be fired with accuracy in one minute. Two feathers in an arrow were to be white, and one brown or grey, and this difference in colour informed the archer in an instant how to place the arrow.

Advantages
of the long-
bow.

Although arrows could be shot from a bow with far greater rapidity and precision than balls from a musket, yet in damp weather the bow and string might become so much relaxed that the efficacy of the instrument became much impaired. A side wind deflected the arrow exceedingly in its flight, and even against a moderate wind, it was difficult to shoot at all.

Disadvanta-
ges of the
long-bow.

Our Forefathers encouraged to acquire skill in archery by legal enactments, and by the founders of our public schools.

1st. BY LEGAL ENACTMENTS.

We have previously stated that the first law encouraging the practice of archery was passed in the reign of Henry II.

An Act of Parliament was passed in the reign of Richard II., to compel all servants to shoot on Sundays and holidays.

In the reign of Edward IV., an act was passed, ordaining every Englishman to have a bow of his own height, and during the same reign butts were ordered to be put up in every township for the inhabitants to shoot at on feast days, and if any neglected, the penalty of one halfpenny was incurred. The same monarch also passed an act, that bows were to be sold for 5s. 4d.

Henry 2nd
from 1154 to
1189.

Richard 2nd
from 1377 to
1399.

Edward 4th
from 1461 to
1483.

Every man to
have a bow.

Henry VII. prohibited the use of the cross-bow, and Henry VIII., less than twenty years after, renewed the prohibition. He forbade the use of cross-bows and hand guns, and passed a statute which inflicted a fine of £10 for keeping a cross-bow in the house. Every man, being the King's subject, was obliged to exercise himself in shooting with the long bow, and also to keep a bow with arrows continually in his house. Fathers and guardians were also commanded to teach their male children the use of the long bow.

Cross-bows
prohibited by
Henry 7th &
Henry 8th.

Encouraged
by Philip and
Mary.

A statute of Philip and Mary mentions the quantity and kind of armour and weapons, to be kept by persons of different estates, viz :—"Temporal persons having "£5 and under £10 per annum, one coat of plate furnished, one black bill or halbert, "one long bow, one sheaf of arrows, and one steel cap or skull."

Prices fixed
by Elizabeth.

An act of Elizabeth, fixed the prices for long bows, at 6s. 8d., 3s. 4d., and a third sort at 2s. each bow.

Encouraged
by monarchs
from Henry
8th to Charles
1st.

Numerous statutes were passed to encourage archery in the reigns of Henry VIII., Elizabeth, James I. and Charles I. in whose reign the legislature interfered for the last time in 1633, when Charles I. issued a commission for preventing the fields near London being so enclosed, "as to interrupt the necessary and profitable exercise of "shooting," and also a proclamation for the use of the bow and pike together :—

Proclamation
by Charles
1st.

"A. D. 1633.—Whereas in former tyme bowes and arrowes have been found service-
"able weapons for wars, whereby great victories and conquests have been gotten, and
"by sundry statutes the use thereof hath been enjoined, &c. &c.—and we expect that
"our loving subjects should conform themselves thereunto, knowing the exercise of
"shooting to be a means to preserve health, strength and agility of body, and to avoid
"idleness, unlawfull disports, drunkenness, and such like enormities and disorders,
"which are too frequent among our people."

2ND.—BY THE FOUNDERS OF OUR PUBLIC SCHOOLS.

Estimation of
archery by
founders of
schools.

The founders of our Grammar Schools appear to have considered that the acquirement of skill in archery by their scholars was no less worthy of attention than their moral and intellectual improvement. They provided by their statutes sound learning and a religious education for all, but secured the removal of such as shewed no aptitude or disposition to learn. They also prescribed the amusements and exercises of the scholars, and prohibited such as were calculated to lead to idle and vicious habits. In fact, as true patriots, they understood how the sons of free men ought to be educated in youth, and that "a complete and generous education is that "which fits a man to perform justly, skilfully, and magnanimously, all the offices, "both private and public, of peace and war."

Harrow
School,
founded 1571.

The founder of Harrow School, Mr. John Lyon, prepared a body of statutes to be observed in the management of the School. By one of these he limited the amusements of the Scholars "to driving a top, tossing a hand-ball, running, shooting, and "no other." By another he ordered :—"You shall allow your child at all times, "bow-shafts, bow-strings, and a bracer, to exercise shooting." On the entrance-porch to the Master's house are two shields, the one bearing the Lion rampant, the other, two arrows crossed, an ancient device which had its origin in the design of the founder. This device is also impressed on the exterior of all books which are presented by the Head-Master as prizes to those scholars, whose improvement entitled them to such rewards. The practice of archery was coeval with the foundation of the School, and was continued for nearly two centuries. Every year there was a public exhibition of archery, when the scholars shot for a silver arrow. The last silver arrow was contended for in 1771.

At St. Alban's Grammar School, one of the articles to be recited to such as offered their children to be taught in the School was,—“Ye shall allow your child at all times, a bow, three arrows, bow-strings, a shooting glove, and a bracer, to exercise shooting.”

St. Albans
School.

Sir John Dean, who founded, in 1558, the Grammar School of Wilton, in Cheshire, framed a body of statutes for the School. One of them provides:—“That upon Thursdays and Saturdays, in the afternoons, and upon holidays, the scholars refresh themselves, and that as well in the vacations as in the days aforesaid, they use their bows and arrows only, and eschew all bowling, carding, dicing, cocking, and all other unlawful games, upon pain of extreme punishment to be done by the Schoolmaster.”

Wilton
School.

The Free Grammar School of Dedham, in Essex, was endowed in 1571, and confirmed by a Charter of Queen Elizabeth in 1574. Her Majesty's injunctions to the parents of the boys who should attend the school at Dedham were:—“That they should furnish their sons with bows, shafts, bracers and gloves, in order to train them to arms.”

Dedham
School in
Essex.

One of the statutes at the Grammar School of St. Saviour, in Southwark, decrees that “the plays of the scholars shall be shooting in long-bows, chess, running, wrestling, and leaping:—players for money, or betters, shall be severely punished and expelled.”

St. Saviour's
School in
Southwark.

A statute in the same words is found in the rules and orders framed for the government of Camberwell Grammar School, which was founded in 1615, by letters patent.

Camberwell
School.

MEANS BY WHICH SKILL IN ARCHERY WAS ACQUIRED.

A successful archer could only be constituted by long training, strength, and address, we need not therefore wonder that the practice of the long-bow was not more copied by our neighbours, as the French pertinaciously adhered to the use of the cross-bow.

An archer
made by long
training, &c.

Etienne di Perlin, a Frenchman who wrote an account of a tour in England in 1558, says:—“The husbandmen leave their bucklers and swords, or sometimes their bow, in the corner of the field, so that every one in this land bears arms;” and it is also stated that all the youth and manhood of the yeomanry of England were engaged in the practice of the long-bow.

Every man
had arms.

Public exhibitions of shooting with the bow continued during the reigns of Charles II. and James II., and an archer's division, at least till within these few years, formed a branch of the Artillery Company. The most important society of this kind now existing is “The Royal Company of Archers, the King's body-guard of Scotland.” The exact time of its institution is unknown, but it is referred by the Scottish antiquarians to the reign of their James I.

Public
matches.

Roger Ascham, in “Toxophilos,” states that the main difficulty in learning to shoot, arises from having acquired and become confirmed in previous bad habits; so

Causes of bad
shooting.

that, "use is the only cause of all faultes in it, and therefore children more easelye
 "and soner may be taught to shoote excellently then men, because children may be
 "taught to shoote well at the first, menne have more paine to unlearne their ill uses
 "than they have labour afterwarde to come to good shootinge;" and after having
 enumerated a long list of faults ordinarily committed, he thus proceeds to describe the
 secret of shooting straight with the long-bow.

Shooting de-
pends on the
eye.

The hand
obeys the eye.

"For having a man's eye alwaye on his marke, is the only waye to shoote
 "straighthe, yea, and I suppose so redye and easye a waye, if it be learned in youth
 "and confirmed with use, that a man shall never misse therein. Men doubt yet in
 "loking at the marke what way is best, whether betwixt the bow and the stringe,
 "above or beneath his hande, and manye wayes moo. Yet it maketh no greate
 "matter which waye a man loke at his marke, if it be joined with comlye shooting.
 "The diversytye of mens standing and drawing causeth divers men loke at their marke
 "divers wayes; yet they all had a mans hand to shoote straighthe if nothinge els
 "stoppe. So that cumlynesse is the only judge of best lokinge at the marke. Some
 "men wonder whye in castinge a man's eye at the mark, the hande should go streight.
 "Surely if he considered the nature of a man's eye, hee woulde not wonder at it. For
 "this I am certaine of, that no servaunt to his maister, no child to his father, is so
 "obedient as everye joynte and peece of the bodye is to do whatsoever the eye
 "biddes. The eye is the guide, the ruler, and the succourer of all the other parts.
 "The hande, the foote, and other members dare do nothinge withoute the eye, as
 "doth appear on the night and darcke corners. The eye is the very tongue where-
 "with witte and reason doth speake to everye parte of the bodye, and the witte doth
 "not so soone signifye a thinge by the eye, as every part is redye to followe, or rather
 "prevent the bidding of the eye. This is plaine in manye thinges, but most evident
 "in fence and feighting, as I have heard men saye. There every parte standing in feare
 "to have a blowe, runnes to the eye for help, as younge children do to the mother;
 "the foote, the hande, and all wayteth upon the eye. If the eye bid the hand eyther
 "beare of or smite, or the foote eyther go forward or backward, it doth so. And
 "that which is most wonder of al, the one man lokinge stedfastlye at the other mans
 "eye and not at his hand, wil, even as it were, rede in his eye wher he purposeth to
 "smyte next, for the eye is nothing els but a certain windowe for wit to shoote out
 "her heade at. This wonderfull worke of God in making all the members so obedient
 "to the eye, is a pleasant thing to remember and loke upon: therefore an archer may
 "be sure in learninge to loke at his marke when hee is younge alwayes to shoote
 "streight."

The following description of the English archer is from an ancient treatise on
 Martial Discipline:—

Archer to
wear easy
dress.

Captains to
see that bows
&c., were in
good order.

"The yeoman hadde, at those dayes, their lymmes at libertye, for their hoseyn
 "were then fastened with one point, and their jackes were long, and easy to shote in,
 "so that they mighte draw bowes of great strength, and shote arrowes of a yarde long.
 "Captens and officers should be skilful of that most noble weapon, and to see that
 "their soldiers according to their draught and strength have good bows, well nocked,

“well strynged, everie stringe whippe in their nocke, and in the myddes rubbed with
 “wax, braser and shuting glove, some spare strings trymed as aforesaid, everie man
 “one shefe of arrows, with a case of leather defensible against the rayne, and in the
 “same shefe fower and twentie arrows, whereof eight of them should be lighter than
 “the residue, to gall and astoyne the enemy with the hailshot of light arrows, before
 “they shall come within range of their harquebuss shot.”

Twenty-four
arrows to each
man.

The subject of archery was not deemed, in those days, an unsuitable theme for the pulpit, as may be seen by the following extract from one of the seven sermons (the sixth) preached before Edward VI., within the preaching place in the palace of Westminster, on the 12th of April, 1549, by that patriotic reformer, Bishop Latimer. With honest, plain spoken words, in the midst of his discourse he breaks off—

Encouraged
from the
pulpit.

“Men of England, in times past, when they would exercise themselves, (for we
 “must needs have some recreation, our bodies can not endure without some exercise),
 “they were wont to goe abroad in the fieldes a shooting; but now it is turned into
 “glossing, gulling, and whooring within the house. The arte of shooting hath bene
 “in times past much esteemed in this realme, it is a gift of God that He hath geven
 “us to excell all other nations withall, it hath been God’s instrument whereby He
 “hath geven us many victories against our enemies. But now we have taken up
 “whooring in townes, instead of shooting in the fieldes. A wonderous thing that so
 “excellent a gift of God should be so little esteemed. I desire you, my Lordes, even
 “as ye love the honour and glory of God, and entend to remove his indignation, let
 “there be sent forth some proclamation, some sharpe proclamation to the justices of
 “péace, for they doc not thier dutie, justices now be no justices, there be many good
 “actes made for this matter already. Charge them upon their allegiance that this
 “singular benefite of God may be practised, and that it be not turned into bolling,
 “glossing, and whooring within the townes: for they be negligent in executing these
 “laws of shooting. In my time my poore father was as diligent to teach me to shoote
 “as to learne me any other thing, and so I think other men did their children. He
 “taught me how to draw, how to lay my body in my bow, and not to draw with
 “strength of armes as other nations doe, but with strength of the body. I had my
 “bowes bought me according to my age and strength, as I encreased in them, so my
 “bowes were made bigger and bigger: for men shall never shoot well except they be
 “brought up in it. It is a goodly arte, a wholesome kinde of exercise, and much
 “commended in phisicke.”

Training of
Bishop Lati-
mer.

The following is another extract from the same sermon:—

“I came once myself to a place, riding on a journey homeward from London,
 “and I sent word over night into the towne that I would preach there in the morn-
 “ing, because it was a holiday, and methought it was an holidayes work. The
 “church stood in my way, and I took my horse and my company, and went thither,
 “(I thought I should have found a great company in the church,) and when I came
 “there, the church door was fast locked. I tarryed there halfe and houre and more,
 “at last the key was found, and one of the parish comes to me and said: ‘Sir, this
 “is a busie day with us, we cannot heare you, it is Robin Hood’s day. The parish

How estima-
ted by the
people.

"are gone abroad to gather for Robin Hood. I pray you let them not.' I thought "my rochet should have been regarded, though I were not: but it would not serve, "it was faine to give place to Robin Hood's men."

PROOFS OF THE IMPORTANCE OF ARCHERY.

By names of places.

There is little at the present day in England to afford any adequate idea of the high importance, the great skill, and the distinguished renown of the English archers. Some few places still retain names which tell where the bowmen used to assemble for practice, as "Shooter's Hill," in Kent; "Newington Butts," near London; and "St. Augustine's Butts," near Bristol. The Butts will be found applied to spots of land in the vicinity of schools, as for instance, the College School of Warwick.

The fields situated to the east of the playing-fields at Eton, and known by the name of "The Upper and Lower Shooting-fields, were probably so named from the ancient exercise of archery on these grounds.

Armorial bearings.

Many of the noble and county families of Great Britain and Ireland have the symbols of archery charged on their escutcheons; as, for instance, the Duke of Norfolk, the Marquis of Salisbury, Lord Grey de Wilton, the Earl of Aberdeen, the Earl of Besborough, the Earl of Portarlington, the Baronetal family of Hales, Sir Martin Bowes, and also on the arms of Sydney Sussex College, in Cambridge, and the seal of the Sheffield Grammar School.

Government brand.

The mark or brand used by the Government of the present day, to identify public property, is an arrow-head, commonly called "The King's broad arrow."

Surnames of families.

There are also existing families which have derived their surnames from the names of the different crafts formerly engaged in the manufacture of the bow and its accompaniments; as, for instance, the names of Bowyer, Fletcher, Stringer, Arrow-smith, Arrow, Bowman, Bowwater, &c.

National proverbs.

If reference be made to our language, there will be found many phrases and proverbial expressions drawn from or connected with archery; some suggesting forethought and caution, as "Always have two strings to your bow;" "Get the shaft-hand of your adversaries;" "Draw not thy bow before thy arrow be fixed;" "Kill two birds with one shaft." To make an enemy's machination recoil upon himself, they expressed by saying, "To outshoot a man in his own bow." In reference to a vague foolish guess, they used to say, "He shoots wide of the mark;" and of unprofitable silly conversation, "A fool's bolt is soon shot;" and as a proof of exaggeration, "He draws a long bow." The unready and unskilful archer did not escape the censure and warning of his fellows, although he might be a great man and boast that he had "A famous bow, but it was up at the castle." Of such they satirically used to remark, that "Many talked of Robin Hood, who never shot in his bow." Our ancestors also expressed liberality of sentiment, and their opinion that merit belonged exclusively to no particular class or locality, by the following pithy expressions, "Many a good bow besides one in Chester," and "An archer is known by his aim, and not by his arrows." To these may be added, "Testimony is like the shot of a

long-bow, which owes its efficacy to the force of the shooter ; argument is like the shot of a cross-bow, equally forcible, whether discharged by a dwarf or a giant."

MILITARY AND POLITICAL CONSEQUENCES OF SKILL IN THE USE OF THE BOW.

From the time of the battle of Hastings the English archers began to rise in repute, and in course of time proved themselves, by their achievements in war, both the admiration and terror of their foes, and excelled the exploits of other nations. The great achievements of the English bowmen which shed lustre upon the annals of the nation, extended over a period of more than five centuries, many years after the invention and use of fire-arms. England, therefore, in those times, possessed a national voluntary militia, of no charge to the Government, ready for the field on a short notice, and well skilled in the use of weapons. Hence sprung the large bodies of efficient troops which at different periods of English history, in an incredible short time, were found ready for the service of their country. These men were not a rude, undisciplined rabble, but were trained, disciplined men, every one sufficiently master of his weapon to riddle a steel corslet at five or six score paces, or in a body, to act with terrible effect against masses of cavalry ; while most of them could bring down a falcon on the wing by a bird-bolt, or with a broad arrow transfix the wild deer in the chase.

Before the simple weapon of the British archer, itself but a larger form of the simplest plaything of a child, all the gorgeous display of knighthood, the elaborated panoply of steel, the magnificent war-horse, the serried ranks, the ingenious devices of tacticians and strategists, at once gave way ; nothing can withstand the biting storm of the "cloth-yard shaft." It was equally efficacious in the field and in the siege. The defender of town or castle could not peep beyond his bretèche or parapet, but an English arrow nailed his cap to his head. In a field, provided the archers were, by marsh, wood or mountain, secured from a flank attack, they would bid defiance to any number of mounted men-at-arms. Their shafts, falling thick as hail among the horses, soon brought them to the ground, or threw them into utter disorder ; then the armed footmen advanced and commenced a slaughter which was scarcely stayed but by weariness of slaying ; the archers meantime continuing their ravages on the rear of the enemy's cavalry by a vertical attack, prolonged, when the ordinary supply of their quivers had been exhausted, by withdrawing their arrows from their slain enemies, to be sent forth on new missions of death :—here is encouragement for our modern marksmen who are armed with a far more deadly weapon.

The most complete and philosophic digest, which relates to the system of British archery, considered from a military point of view, is that given by the present Emperor of the French in his treatise "*Sur le Passé et l' Avenir de l' Artillerie.*" That the British victory at Cressy was wholly attributable to the prowess of British archers, is well known ; not so well, a circumstance pointed out by the Emperor of the French, that thenceforward, and in consequence of that victory, the prestige of cavalry

Commenced at the battle of Hastings.

Achievement lasted through a period of 500 years.

England had a voluntary army.

Archers defeated men-at-arms.

Value in sieges.

Opinion on English archers by Napoleon III.

Destroyed the
prestige of
cavalry.

Estimation of
infantry by
continental
nations.

Archer a
yeoman.

Political
results.

declined. Now, there is a political, no less than military significance in this lowering of the esteem in which cavalry had previously been held. Horsemen were gentlemen, and infantry men of inferior degree. Whenever and wherever British archery were *not* brought to bear, horsemen were omnipotent, and infantry of little avail. During the fourteenth and fifteenth centuries—the golden age of archery in this land, when yeoman or archers were in such high repute,—France and continental nations generally, treated foot soldiers with disdain. The Emperor of the French, in his systematic book just adverted to, mentions several examples where foot soldiers were ruthlessly cut down and ridden over by their own cavalry—the men-at-arms; not that the infantry fought ill, but that they fought too well. They were slaughtered lest the men-at-arms should have no scope for the exercise of their skill.

English men-at-arms never sullied their fame by cruel acts like these; not that they were better at heart: seeing that human nature is everywhere, and under all circumstances, pretty much alike. English infantry, mainly composed of archers, were far too valuable to be thus used. They bore the first brunt of battle, and not unfrequently decided it. At the time when every other foot soldier in Europe was the merest serf, the British archer was a yeoman. He had a fixed heraldic rank; the first of low degree. He was above the handicraftsman, however skilful,—above the merchant—taking his rank immediately after the gentry. The excellence of British archery, then tended to bring about a political result; helping to establish that middle-class which, ever since its consolidation, has been one of the sheet-anchors of our glorious constitution.

THE ARBALEST, OR CROSS-BOW.

Cross-bow,
modification
of long.

Invented in
Crete or
Sicily.

To England
by Saxons.

The Normans
got cross-
bows from
Italy.

In process of time a modification of the bow was invented. In place of the original instrument, a much shorter and stiffer bow, usually of steel, was placed transversely in a stock, bent by a lever, and discharged by a trigger, after the manner since used for a gun.

The cross-bow, or arbalest, called in Latin, *arcus balistarius*, or *balista manualis*, and in French *arbalèt*, is said by some to be of Sicilian origin; others ascribe its invention to the Cretans. It is supposed to have been introduced into France by the first crusaders, and is mentioned by the Abbé Suger in his life of Louis le Gros, as being used by that Prince, in the beginning of his reign, which commenced in the year 1108.

Verstigan seems to attribute the introduction of this weapon into England to the Saxons, under Hengist and Horsa, but cites no authority in support of that supposition. In a print representing the landing of those generals, the foremost of them is delineated with a cross-bow on his shoulder, and others are seen in the hands of the distant figures of their followers, landed and landing from their ships.

It would appear that the Normans derived the cross-bow, with its name, from Italy. In Domesday Book mention is made of Odo, the arbalester, as a tenant in capite of the king of lands in Yorkshire; and the manor of Worstead, Norfolk, was

at the time of Domesday survey, held of the Abbot of St. Benet at Holme, by Robert the cross-bow man. The names show them to have been Normans, and these instances are sufficient to prove the introduction of the weapon, though the few that may have been used at the battle of Hastings might occasion its not being represented in the Bayeux tapestry.

The absence of the cross-bow in early Roman monuments leaves it a matter of doubt, whether an arbalester would not simply mean the engineer of a catapult. There is no mention made of the hand cross-bow in very ancient authorities.

The cross-bow has been used in England (at least, on hunting excursions) in the time of Rufus, for Wace tells us, that "Prince Henry, going the same day to New Forest, found the string of his cross-bow broken, and taking it to a villain to be mended, saw an old woman there, who told him he should be king."

During the reign of Henry I. the cross-bow seems to have been principally used in the chase. The projectile was in form of a short arrow, with a pyramidical head, called a quarrel, (plate 14, fig. 2 and 4). Simeon of Durham speaks of it in the time of Henry I. thus:—"He raised a machine from whence the archers and cross-bowmen might shoot."

The Genoese were at all times most celebrated for the skilful management of the cross-bow. The success which attended the Christians at the siege of Jerusalem, 1100, is attributed principally to the mechanical talents of this people.

The use of the cross-bows was general in Italy in 1139, for at that time Pope Innocent II. particularly forbade them. The German Emperor Conrad did the same, as we learn from William de Dole, who lived in the latter part of the 12th century, they not being looked upon as a fair weapon.

It is said of Richard I.:—"Truly he revived the use of this kind of shooting, "called cross-bow shooting, which had long since been laid aside, whence he became "so skilful in its management, that he killed many people with his own hand." It is supposed that Richard I. first used the cross-bow as a weapon of war at the siege of Acre. In every action, however, of which we read in the history of the second crusade, as well as the third, in which Richard participated, cross-bows, as well as other bows, are repeatedly noticed. It is stated that he was killed by an arrow, said to have been shot from a cross-bow at the Castle of Chalus.

From the beginning of the 13th, and until the middle of the 15th century, cross-bow men are uniformly mentioned as part of the Genoese troops. From Justinus we learn, that in 1225 "Twenty Arbalestes mounted, and one hundred on foot, with "cross-bows of horn, were then employed in the army of the state."

The cross-bow man was an essential component of the host during all this period. He was in the van of the battle.

In the battle near Damietta, in 1237, "more than a hundred knights of the "Temple fell, and three hundred cross-bow men, &c., &c."

The Emperor Frederic, in 1239, giving an account of his Italian campaign to the king of England, writes: "After we had, by our knights and cross-bow men, reduced "all the province of Liguria," &c.

No cross-bow
among
Romans.

William II
surnamed
Rufus, from
1087 to 1100

Henry I, 1100
to 1135.

Cross-bow in
war.

Genoese
celebrated for
the use of.

Use of forbid

Richard I
from 1189 to
1199.

Siege of Acre

Universal in
Crusades.
Richard
killed by.

Genoese
cross-bow
men.
Mounted
Arbalests
1225.

Battle near
Damietta
1237.

Campaign in
Italy 1239.

- Genoese 1245 Five hundred Genoese cross-bow men were sent against the Milanese in 1245, and these unfortunate men being placed in front of the line, were taken prisoners by the enemy, who, to revenge themselves for the havoc done by their bows, cruelly punished each with the loss of an eye, and amputation of an arm.
- Treatment of.
- Cross-bows at Cressy 1346. There were 15,000 Genoese cross-bow men in the front rank of the French army at the battle of Cressy, 1346.
- At siege of Le Roche de Ri n. The next year we find that Charles, Earl of Blois, had at the siege of Le Roche de Ri n no less than 2,000 in his army.
- Corporation of Arbalisters 1359. The "Corporation des Arbalestriers de Paris," in 1359, consisted of two hundred members. In 1373, their number, as fixed by a royal ordinance, was eight hundred. They were not bound to serve beyond the limits of their district without the consent of the Provost of Paris. There were both foot and mounted cross-bowmen in this body.
- Cross-bow encouraged by Edward III. Edward III., though he wished principally to encourage the long-bow, could not help seeing the advantages which might be derived from the cross-bow, from the accuracy of its shot, and its convenience on horseback. It does not appear that, in the long wars of Edward with the French in this century, cross-bowmen were raised in England, though they were supplied by Genoese contractors on various occasions for service at sea. In 1363 the king caused public proclamation to be made, in order to encourage its use.
- No English in wars of Edward III.
- Genoese mercenaries.
- Matches. There were also matches made in different parts of Europe, at which prizes were given to the most skilful cross-bowmen.
- Mounted cross-bow men in France 1373. In the list of the Grand Masters of the Arbalesters of France under Charles V., in 1373, appears "Marc de Grimant, Baron d'Antibes, Captain-General of Arbalesters, "both foot and horse, in the service of the king." And a similar notice occurs in the reign of King John, Baudoin de Lence being Grand Master; but it would appear that the mounted cross-bowmen were retained in much smaller numbers than the foot.
- "Pavisers." During the reign of Edward III. cross-bowmen seem first to have been protected by "Pavisers," (plate 15), or men who held before them a large shield called a "Pavise."
- Pavisers by English 1404. On the attack by the French and Spaniards upon the Isle of Portland in 1404, the English formed pavisers to protect themselves from the cross-bow bolts, by taking the doors from their houses, and fixing them upright by props. Under this cover the archers plied their arrows.
- Cross-bow not esteemed by English. The English never had much esteem for the cross-bow in the field. Among the 10,500 men led out of England by Henry VI., in 1415, there were only ninety-eight Arbalesters, of whom eighteen were horsemen; nevertheless, Henry VII. found it necessary to prohibit the use of the cross-bow in 1508, and, seven years after, another statute was passed, renewing the prohibition. This interference, however, of the legislature does not seem to have produced the intended effect, for in less than twenty years later the use of the cross-bow had become so prevalent, that a new statute was judged requisite, which inflicted on every person that kept one in his house, the penalty of twenty pounds. It is from this period, therefore, that we may date the
- Forbad by Henry VII 1508 & 1515.
- Forbad by Henry VIII 1535.

decline of the arbalest in this country, as these statutes produced by degrees the reformation sought for. Not a single cross-bow man is to be seen in the paintings belonging to the Society of Antiquaries, nor at Cowdray House, representing the battles of Henry VIII., and painted at the period; and, to give a finishing blow, another statute soon followed, still more decisive.

Decline of
cross-bow.

DESCRIPTION OF CROSS-BOW.

The ancient cross-bow, which differed in many particulars from those of late times, is thus described by Father Daniel, who formed his description from one or more then before him.

Description.

The cross-bow was an offensive weapon, which consisted of a bow fixed to the top of a sort of staff, or stock of wood, which the string of the bow, when unbent, crossed at right angles.

The handle or bed, which was called the stock of the cross-bow, had towards the middle a small opening or slit, of the length of two fingers, in which was a little moveable wheel of solid steel; through the centre of it passed a screw that served for an axis; this wheel projected a little beyond the surface of the stock, and had a notch, or catch, which stopped and held the string of the bow when bent. In the opposite side of the circumference was a much smaller notch, by the means of which the spring of the trigger kept the wheel firmer, and in its place; this wheel is called the nut of the cross-bow. Under the stock, near the handle, was the key of the trigger, like that of the serpentine of a musket; by pressing this key with the hand, to the handle of the cross-bow, the spring released the wheel that held the string, and the string by its motion drove forward the dart.

Stock.

Trigger.

Upon the stock below the little wheel was a small plate of copper, which lifted up and shut down, and was fixed by its two legs, with two screws to the two sides of the stock; this was a back-sight; it was pierced above by two little holes, one over the other, and when the plate was raised, these two holes answered to a globule, which was a small bead, no bigger than that of a chaplet, that was suspended at the end of the cross-bow by a fine wire, and fastened to two perpendicular columns of iron, one on the right, the other on the left, and this little globule, answering to the holes in the plate, served to direct the aim, whether for shooting horizontally, upwards, or downwards.

Back-sight.

Fore-sight.

The cord or string of the bow was double, each string separated by two little cylinders of iron, equi-distant from the extremities of the bow and the centre; to these two strings in the middle was fixed a ring of cord, which served to confine it in the notch previously mentioned when the bow was bent. Between the two cords in the centre of the string, and immediately before the ring, was a little square of cord, against which was placed the extremity of the arrow or dart, to be pushed forward by the cord.

Cord.

The smaller cross-bows were bent with the hand; the larger ones were at first bent by the soldier placing his foot in a stirrup, attached to the end of the bow; a cord

Bent by hand
By foot.

By pulley. was then fixed by one end to the butt of the stock, the other end being fastened to a waistbelt. A pulley, running upon the cord, was hooked to the bowstring, and the bow was then bent by raising the body and keeping the leg firm.

By moulinet. The cross-bow was afterwards furnished with the moulinet and pulleys, (plate 13) which after the bow had been bent, could be removed for the discharge; these consisted of an iron cylinder in a frame of the same metal, made to turn by two moveable handles in opposite directions, and having a cap likewise of iron to fit on the butt end of the stock. On each side of this cap was a small pulley, the wheel of which was one inch and a half in diameter, having attached to one of its arms a strong cord that passed thence round an equal sized wheel, returned over the first, and then went round one double in diameter, situated beyond the second, and so passed to the cylinder of the moulinet, by winding which, the power required to bend the bow was lessened to one fourth. Attached to the arms of the greater wheels was a double claw, made to slide on the plane of the stock, which, catching hold of the bowstring, drew it up to the nut. An improvement of the moulinet was, that the handles of the cylinder were both made in the same line, instead of being one up and the other down.

By windlass. At a later period the cross-bow was bent by a windlass, which consisted of a bar of iron, shaped at its end into a claw, and having teeth the whole length of one edge. This slipped through an iron box, containing a wheel, the cogs of which fitted the teeth of the bar, and as a handle was fixed to the axle, on turning it the string was wound up. This apparatus was attached by a loop, which slipped over the stock, and was kept in its place by two iron pins, that projected from the side, and then, when bent, it could be easily removed.

By steel lever. Another mode of bending the cross-bow was by means of a steel lever, called the goat's-foot lever, which was moveable. This was formed of two legs, a catch and a handle, all acting on one pivot. The legs were applied to the projecting pieces of iron on each side the stock, and then the purchase was very great.

Latch. There were two principal varieties of cross-bows, viz., the "Latch," with grooved stock, for "quarrels," and the "Prodd," for bullets. (Plate 14, fig. 1 and 2.)

Prodd. In the reign of Henry VI. the stocks of cross-bows were made of hard wood, Dimensions and form of latch. ornamented with ivory. They were about three feet three inches long, the bow of steel, about two feet eight inches from end to end, weighing in all about fifteen pounds. The length of the groove for the quarrel about one foot four inches. The arrows discharged were called both quarrels and viretons, (plate 14, fig. 2 and 4,) Quarrels viretons. some with feathers, others without. The vireton is a French name; the feathers being set on a little curved, made it spin round as it passed through the air.

Arquebus or barrelled cross-bow. It is stated by Captain Panôt, that the Arquebus was in use before the invention of powder, and was but an improvement on the arbalest, or cross-bow. The Arquebus, like the cross-bow, had a stock, upon which was fixed a tube, intended Slit in tube. to receive the projectile. This tube was split, for the passage of a cord, which was held back by a kind of sheave or pulley, which communicated motion to the projectile, on the trigger being pulled. In general, leaden balls were fired from the Fired leaden balls. arquebus. The barrelled cross-bow was suggested by the "balista grossa de arganellis," which was furnished with tubes for ejecting Greek fire.

In the United Service Museum, Whitehall, there is a cross-bow of Cingalese manufacture. It strings itself, and discharges two arrows each time in rapid succession, until the magazine is exhausted, which contains twelve arrows, and may be replenished in a moment.

Repeating
cross-bow.

It is evident that the different sizes and various powers of cross-bows occasioned a great diversity in the distance of their range. Thus, in Henry 5th's time the range of the cross-bow is stated to have been forty rods (220 yards), and it never appears to have been more powerful than at that period.

Range in
Henry V.

M. de Bellay says that the cross-bowman will kill at 100 or 200 paces, which gives a great range to the arbalests of Elizabeth's time.

Range in
Elizabeth's

Sir John Smith, however, in his observations, not long after this, very much contracts the distance of their shot, for he says that "a cross-bow will kill point-blank between 40 and 60 yards, and, if elevated, 120, 140, or 160 yards, or further."

The former probably alluded to the prod, the latter to the latch.

COMPARATIVE MERITS OF THE LONG AND CROSS BOW.

How inefficient the cross-bow was found, when opposed by English archery, appears in every page of the histories of the fourteenth century.

The superiority of the long-bow mainly depended upon the strength and skill of the archer, while a greater amount of accuracy at shorter ranges could be had out of the cross-bow, with much less training; and the success of the English archers when opposed to cross-bowmen may be mainly ascribed to the more "rapid" fire of the former.

Why long-
bow superior.

It is generally conceded that the long-bow could deliver at least six shafts while the cross-bow discharged one; and, with such odds against them, it became impossible for the bravest and most expert troops, whether at Cressy or elsewhere, to make a stand against their opponents.

Celerity the
great advan-
tage of the
long-bow.

On the other hand, the cross-bow was decidedly a more convenient weapon on horseback than the long-bow.

Cross-bow
best on horse-
back.

COMPARATIVE MERITS BETWEEN BOWS AND EARLY FIRE-ARMS.

The invention of gunpowder, and its application to artillery and small arms, did not produce that sudden change in the art of war, or in weapons, that might, on a first consideration, have been expected. Many of the old soldiers were much divided in their opinion of the superiority of fire-arms, nor does it appear that the government of those days were decided upon it, as the strongest statutes for enforcing the practice of archery were enacted after their introduction.

Joshua Barnes, in his life of Edward III., observes, that "without all question, the guns which are used now-a-days, are neither so terrible in battle nor do such execution nor work such confusion as arrows can do; for bullets, being not seen, only hurt

Long-bow
preferred in
Edward III.

where they hit, but arrows enrage the horse, and break the array, and terrify all that behold them in the bodies of their neighbours. Not to say that every archer can shoot thrice to a gunner's once, and that whole squadrons of bows may let fly at one time, when only one or two files of musqueteers can discharge at once. Also, that whereas guns are useless when your pikes join, because they only do execution point-blank, the arrows which will kill at random may do good service even behind your men of arms.

Although fire-arms had attained no inconsiderable degree of perfection in the reign of Henry VIII., yet the long-bow was still the favourite weapon.

So indifferent were the ministers of Queen Mary respecting them, that in her ordinance respecting armour and weapons, the alternative is left to the choice of the people, whether they should find a long-bow and sheaf of arrows, or a haquebutt, in every case where they were by law charged with the latter.

In the reign of Elizabeth, the musket was so slow to charge and discharge that the bow was considered superior by many; and Mons. de Bellay states that if archers and cross-bowmen could carry their arrows, &c., as easy as harquebusiers do their ammunition, he would prefer the former weapon over the latter.

The effects of arrows sticking in horses, are said to have been frightful. This can be easily imagined. A fire-arm bullet can be shot quite through a horse without causing the animal to show one sign of anguish. He goes steadily on his previous course, and makes no sign. However fatal of necessity, a fire-arm bullet gives no immediate pain. Not so the arrow. Planted never so lightly in a horse's neck or flank, the animal grew furious. Starting off into a wild gallop to escape the barbed sting, the animal had no respite for his agony. The wilder the pace, the greater the pain. Far from the serried squadrons where he fain would be, sore against his will, rushed the mail-clad knight. Plunging and rearing, the steed would throw him at last, amidst the dead and dying; himself to die.

Though comparatively few men or horses were killed by arrow wounds at once, few, nevertheless, recovered. The barbed arrow-head was immeasurably more dangerous, imbedded in the flesh, than a mere lump of lead. Hundreds of men, hale and well to-day, have had fire-arm bullets imbedded in their flesh for years. Not so in the time of archery. The arrow-head must be extracted, or mortification came on, and soon a cruel death. Neither was the surgical process of extraction often happy in the results. It would not be easy to extract a barbed arrow-head even now, with all the appliances of modern surgery at hand.

Another fatal consequence of arrow wounds on the field of battle was this: men wounded thus were rarely taken prisoners. Arrows were expensive ammunition. The battle over, detachments were sent out to collect them; and the collection was not done too tenderly. To regain an arrow seemed a far more meritorious act than to save the life of an enemy. The throat of many a wounded wretch was mercilessly cut, that he might be quiet whilst the arrow was being extracted.

The defects of archery were these:—the ammunition was expensive, and when lost, not easily replaced. The flight of arrows is never correct on a windy day, from whatever direction the wind may blow. Rain relaxes the bow and bowstring, so that

Long-bow the favourite in Henry VIII.

Merits balanced in Queen Mary's reign.

The lighter ammunition of the harquebus an advantage.

Arrows make more severe wounds than bullets.

Arrow wounds more fatal.

Bows useless in wind.

In rain.

archery then is of little use. All these are serious defects; but there was another of more importance still. When the archer's ammunition was all expended, he was nearly powerless. A sword, indeed, he carried, for close fighting; and each archer stuck into the ground before him a sharp pointed stake as a protection against cavalry.

The great advantage of the hand-gun was from its penetration, as no armour could keep out balls, but the *silent* discharge of the cross-bow rendered it superior in the pursuit of timid animals, and the prodd has continued in use to the present day, for the purpose of killing deer, rooks, and rabbits.

Hand-gun
most penetra-
tion.
Silent dis-
charge in
favor of bows.

NOTE.—The articles on ancient Engines of War, and upon the Bow, are principally taken from the following works, viz :—"Military Antiquities," by F. Grose, Esq.; "A Critical Inquiry into Ancient Armour," by Sir S. R. Meyrick; "Ancient Armour and Weapons in Europe," by John Hewitt; "Projectile Weapons of War," and Report of the Rifle Match at Wimbledon Common," by J. Scoffern, M.B.; "Engines of War," by H. Wilkinson, and "The Long-Bow of the Past and the Rifle for the Future," by H. Britannicus.

HISTORY OF ARTILLERY.

Fate of nations depends on arms.

There is no subject more intimately connected with the history of the world, from the remotest antiquity than the history of Arms, the fate of nations having always depended either on the superiority of the Arms employed, or on the superior discipline or dexterity of those who used them, wholly independent of the numbers by which they were opposed.

Artillery includes all war-engines.

Before the introduction of gunpowder, all kinds of weapons, both offensive and defensive, were included in the term "Artillery," which has since become restricted to the larger kinds of fire-arms, such as guns, mortars, howitzers, rockets, &c. Thus we find in the I. Saml. xx., 40, "And Jonathan gave his artillery to his lad," when speaking of bows and arrows. Again, in the 20th, Henry VIII., a patent was granted to Anthony Knevt and Peter Mentas, "to be overseers of the science of Artillery;" and in an enumeration of the different species of Artillery, printed in 1594, are reckoned "long-bows, cross-bows, slur-bows, stone-bows, scorpions, and catapultas."

Definition of Artillery.

The root of the word "artillery," is the Latin word "*ars*," an "art." It has been fantastically derived from the Italian *arte di tirare*, the art of firing. In the fourteenth century the science of war-engines was called *artemonie*, and its productions *artillerie*, from the old French word *artiller*, "to employ art." Some writers state that the word "artillery," is derived from *arcus* "a bow," the earlier species of artillery being termed *arcualia*.

First invention unknown

It is difficult to determine with any degree of accuracy the epoch at which gunpowder and its resultants, fire-arms, were first employed for the purposes of war in any part of the world; and this difficulty is increased, at least, as far as regards Europe, from the fact, that the first engines of war, depending on the use of gunpowder, were named after the old machines for throwing darts, stones, &c.

Names of guns from old machines.

First mention of guns.

The earliest account which we have of gunpowder, where it is mentioned as applied to fire-arms, exists in a code of Gentoo Laws, and is thought by many to be coeval with the time of Moses. The notice occurs in the Sanscrit preface to the Code of Gentoo Laws, translated by Halhed, at page 53, viz:—"The Magistrate shall not "make war with any deceitful machine, or with poisoned weapons, or with *cannon or guns*, &c." Halhed observes: "It will no doubt strike the reader with wonder to "find a prohibition of fire-arms in records of such unfathomable antiquity, and he will "probably hence renew the suspicion, which has long been deemed absurd, that "Alexander the Great did absolutely meet with some weapons of this kind in India, "as a passage in Quintus Curtius seems to ascertain."

The Greek fire seems to have been one of the earliest attempts in Europe at the manufacture of a military combustible; but there is some reason to believe that the Chinese had become acquainted with the nature of gunpowder long before the introduction or invention of the aforementioned substance; and they appear to have been the first who took any steps in its manufacture, or in that of weapons of war resulting from its use. Amongst the machines constructed by this extraordinary people, was one called "the thunder of the earth," which is thus described by M. Reinaud; and M. Favé: "A hollow globe of iron was filled with a bucket of gunpowder, mixed "with fragments of metal, and was so arranged, that it exploded on the approach of "an enemy, so as to cause great destruction in his ranks." The "impetuous" dart of the Chinese, was a round bamboo, about two and a half feet in length, lashed with hempen cords to prevent its splitting, and having a strong wooden handle fixed to one end, thus making its entire length about five feet. This was then charged with powder of different kinds, arranged in layers, over which were placed fire balls, which being thrown to a distance of thirty or forty yards by the discharge, consumed any combustible materials they might come in contact with.

A late writer, M. Paravey, has in a great measure established the fact, that gunpowder and fire-arms were known to the Chinese long before the Christian era; and it is mentioned in Chinese writings, that in the year 618 B. C., a gun was in use, bearing this inscription, "I hurl death to the traitor, and extermination to the rebel."

Guns are said to have been constructed in China, in 757 A. D., for the purpose of throwing stones of the weight of from ten to fourteen pounds to a distance of 300 paces. Whatever doubts may exist as to the earlier history of artillery among the Chinese, it is almost beyond question, that cannon were extensively used by them in the beginning of the 13th century, as we have access to various reliable accounts, establishing this fact.

Condé, in his history of the Moors in Spain, states that artillery was used by them against Saragossa in 1118 A. D., and that in 1157, A. D. they defended themselves in Niebla, against the Spaniards, by means of machines, which threw darts and stones, through the agency of fire.

In 1232 A. D. cannon throwing stone shot were used against the Moguls, and during this war, certain machines were also employed, which being filled with powder, and ignited at the proper time, burst with a noise like thunder, and whose effect extended for the space of half an acre round the spot where they exploded.

A small brass cannon is said to have been found at the bottom of a deep well of the Castle de Clucy, in France, with the date 1258 upon it.

In 1280 A. D., cannon were used against Cordova, after which period, they are frequently mentioned in the records of Spain. Iron shot appear to have been first used in that country in the beginning of the 14th century.

Cannon are described by Arabian authors as early as 1312.

The first mention we have of the use of fire arms, after this period, is in the life of Robert Bruce, by John Barbour, Archdeacon of Aberdeen, in which certain engines termed, "crakeys of war," are spoken of, as having been used by Edward III., in his campaign against the Scots, in 1327.

Greek fire, earliest European combustible.

Gunpowder known before in China.

Chinese explosive shell.

Early Chinese cannon.

Guns in China, 618 B.C.

A.D. 757.

Artillery at Saragossa, A.D., 1118.
At Niebla, A.D., 1157.

Used against the Moguls, A. D. 1232.

Cannon bearing date 1258 found in France.
Cannon used against Cordova, A.D. 1280.
Iron shot, 14th century.
Cannon used by Arabians, 1312.

Cannon in
France, 1338.

It is generally believed that cannon were commonly employed in Europe since 1338, as they were used by the French in that year to demolish some castles.

Siege of
Algesiras,
1342 to 1344.

Gunpowder is said to have been used at the siege of Algesiras by Alphonse of Castile against the Moors, 1342 to 1344.

Cannon at
Cressy, 1346.

Edward III. had four guns at the battle of Cressy, 1346. Froissart mentions these guns in one of his manuscripts, now preserved in the library of Amiens. A free translation of the passage referred to would run as follows: "And the English caused 'to fire suddenly certain guns which they had in the battle, to astonish (or confound) 'the Genoese.'" Vilani, a Florentine historian, also confirms this statement, as well as a passage in the chronicles of St. Denis, which speaks of the use of cannon by the English at Cressy. An ancient manuscript also mentions the existence of gunners and artillerymen, whom Edward III. employed when he landed before Calais in 1346, and the several stipends each soldier received. The sentence runs thus: "Masons, 'carpenters, engineers, gunners, and artillerymen, the sum of 12, 10, 6, and 3 'pence per diem."

Cannon of two
kinds.

The first fire-arms appear to have consisted of two kinds; a larger one for discharging stones, called a bombard, (plate 18, fig. 3) and a smaller for propelling darts and leaden balls, both of which were used in 1356, by the Black Prince, to reduce the castle of Romozantin; and two years later, the artillery of St. Valery did great execution among its besiegers.

Used by the
Black Prince,
1356.

At St. Valery,
1358.

Cannon made
in England,
1377.

Cannon were made in England in the fourteenth century, and Richard II. commissioned Sir Thomas Norwich to buy two great and two small cannon in London, or in any other place; and also 600 balls of stone for cannon and for other engines, to be sent to the Castle of Bristol.

Cannon at St.
Malo.

When the English unsuccessfully besieged St. Malo, 400 cannon are said to have been used, but these are supposed to have been of the smaller kind, called hand cannon, or culverins, which were carried by two men, and fired from a kind of tripod or rest fixed in the ground.

Cannon
general.

From this period, cannon were used in all the offensive and defensive operations of war; though a considerable time elapsed before it became a really serviceable arm for field operations. The earlier kinds of cannon were called bombards or bombardæ. Those first employed were clumsy, (plate 16) and ill contrived, wider at the mouth than at the chamber. They merely consisted of bars of iron, arranged in such a manner that their internal aspects should form a tube. The bars were not welded together, but merely confined by hoops. They were also made of iron bars over a cylinder of copper, strengthened by iron hoops, driven on red hot, and others were entirely composed of copper. Bronze was also employed in the manufacture of artillery, as well as thin sheets of iron rolled together; and guns made of leather, and coiled rope, over a cylinder of copper or gun metal, were also introduced, and continued in use for a considerable time. Guns also appear to have been made of wood.

Bombards
made of iron.

Bronze.
Leather, rope,
&c.

Wood.

Rope mortar
at Venice.

In the arsenal at Venice there is an ancient mortar, constructed of leather and rope, used in the siege of the island of Chioggia, near Venice, against the Genoese, 1380. The shot is of stone, 14in. in diameter.

It has been heard recently, that the Chinese constructed their cannon of prepared paper, lined with copper.

Cannon of paper.

As early as 1380 it is said the French were able to procure for the invasion of Italy, a great number of brass cannon, mounted on carriages, and drawn by horses, instead of oxen; these pieces threw balls of from 40lbs. to 60lbs. in weight and could always keep pace with the army. (Plate 18, fig. 1, 3, and 4.)

Field cannon to keep up with army, 1380.

A cannon taken at the siege of Dien in 1546, by John de Castro, and now in Lisbon, is 20 feet 7in. in length, 6 feet 3in. in diameter in the middle, and threw a ball of 100lbs. A Hindostani inscription on it states that it was cast in 1400.

Large cannon 1400.

Bolts and quarrels were shot from cannon in the reign of Henry V.; these were succeeded by stones, as he ordered in 1418, "labourers to make 7,000 stones for the guns of different sorts from the quarries of Maidstone." We learn from Elam's life of Henry V., that when an English army, commanded by the Duke of Gloucester, besieged Cherbourg in 1418, the besieged discharged *red-hot* balls of *iron* from their cannon into the English camp, to burn the huts. So much time elapsed between the loading and discharging the great guns, that the besieged had sufficient time to repair at their leisure, the breaches made by the enormous stones, &c., thrown from them.

Bolts and quarrels shot, 1413.

Red-hot iron balls used at Cherbourg, 1418.

Slow to discharge.

Five wrought-iron bombards are preserved in the Musée de l' Artillerie, at Paris; which were, it is said, abandoned by the English, at the town of Meaux, in 1422.

Cannon at Meaux, 1422.

About the middle of the fifteenth century, the ancient method of constructing cannon was exchanged for that of casting. A hard or mixed metal was invented called "font metal" or bronze, and cannon were then cast in one piece, and instead of fanciful names, they began to be indicated by the weight of their ball, as at present.

Cannon cast, 1450.

At the siege of Constantinople, by Mahomet II., stones were thrown weighing 1,200lbs.! The cannon employed could not be discharged more than three or four times a day. This siege was distinguished by the re-union of ancient and modern artillery; the small arms of the Christians discharged five, or even ten balls at the same time, as large as walnuts; and one piece made for the Turks, by Urban, a Dane, cast a stone bullet weighing 600lbs., which could be discharged seven times a day, but it ultimately burst. This gun was cast of brass at Adrianople, of stupendous and almost incredible magnitude; twelve palms is assigned to the bore. A vacant space before the palace was chosen for the first experiment, but to prevent the sudden and mischievous effects of astonishment and fear, a proclamation was issued that the cannon would be discharged on the following day. The explosion was felt or heard in a circuit of 100 furlongs, the ball was driven above a mile and buried itself a fathom in the ground. A carriage of thirty waggons was linked together to carry the gun along, and drawn by a team of sixty oxen; 200 men on both sides were stationed to poise or sustain the rolling weight, 250 workmen marched before it to smooth the way, and repair the bridges, and near two months were employed in a laborious journey of 150 miles. This enormous gun was flanked by two of almost equal magnitude, and fourteen batteries, mounting 130 guns, were brought to bear upon the place. The cannon were intermingled with machines for throwing stones and darts.

Siege of Constantinople, 1453.

Small guns with several barrels.

Large brass gun, cast at Adrianople.

The Scots had a kind of artillery peculiar to themselves, called "Carts of War."

Artillery of Scots 1496.

- They are described in an Act of Parliament, thus "ilk Cart twa gunnis and ilk ane to have twa Chalmers and an Cumrand man to shute theme." These were breech-loaders, and in 1471, the Barons were commanded to provide such "Carts of War" against their old enemies the English. (Plate 18, fig. 1.)
- Breech-loaders.
- Cannon named.
- Cause of improvements. Iron balls in England, 15th century.
- Iron guns cast
- Hand-culverines.
- Organ-guns.
- Mortars, Henry VIII.
- Shells.
- Varieties of cannon.
- Queen Elizabeth's Pocket-pistol.
- Mons Meg.
- Field-guns, 1554.
- It was not uncommon to give strange names to early cannon; thus Louis XII. had twelve brass ones cast in 1503, of enormous size, which he named after the twelve Peers of France; the Spaniards and Portugese christened theirs after their Saints, and the Emperor Charles V. had twelve when he went against Tunis, which he named after the Twelve Apostles.
- As a knowledge of the art of gunnery increased, great improvements took place with regard to projectiles; and balls of iron were substituted in the place of those formed of stone, being introduced into England in the sixteenth century.
- Iron guns were not cast in this country until the year 1547, foreigners being generally employed to manufacture them. Both Henry VII. and Henry VIII. took great pains to introduce the art of gunnery into the kingdom; and to this end, had a number of Flemish gunners in their daily pay; in fact, it is said, that the latter monarch himself, invented small pieces of artillery to defend his waggons. The earlier species of field artillery, embraced among others, a small kind of ordnance called, "hand cannon," or culverins, which were so light and portable, that they could be carried and served by two men; they were fired from a rest, placed on the ground; also "ribandequins" or organ guns; these latter consisted of a number of tubes, placed in a row, like those of an organ, and appear to have been of French origin, as were many of the improvements which took place about that period, including the invention of wall pieces, throwing leaden balls of ten to the pound.
- For mortars we are indebted to workmen of Henry VIII. as "one Peter Bawd and one Peter Vancollen, both the king's feed men, devised and caused to be made certain mortar pieces, being at the mouth from eleven to nineteen inches wide, and also certain hollow shot of cast iron, to be stuffed with fire-work or wild-fire, for to break in pieces the same hollow shot." And in the first year of Edward VI. the said Peter Bawd did make ordnance of iron of divers forms, as fawconet, fawkons, minions, sakers, &c. His servant, J. Johnson, did like make and cast iron ordnance cleaner and to better perfection, to the great use of this land. His son Thomas Johnson, in 1593, made forty two cast pieces of great ordnance for the Earl of Cumberland, demi cannon, weighing 5,000lbs. or three tons the piece. At Dover there is a culverine, presented to Queen Elizabeth, by the States General of Holland, and called Queen Elizabeth's Pocket-pistol. It is 24 feet long, diameter of bore $4\frac{1}{2}$ inches, weight of shot 12lbs.; it was manufactured in 1544, and is mounted on an ornamented iron carriage made in 1827, at the Royal Carriage Department, Woolwich Arsenal. (Plate 17, fig. 2.)
- There is a large gun at Edinburgh Castle, called Mons Meg; it measures about 13 feet 4 inches in length, the diameter of the bore is about 1 foot 6 inches; it has chamber about 4 feet long and 6 inches in diameter. (Plate 17, fig. 3.)
- The battle of Remi, in 1554, was the first action in which light field guns, having limbers, were used,—these guns accompanied the cavalry.

Pere Daniel says that red-hot iron shot were used by Marshal Matignan, during the siege of la Fère, in 1580.

Red-hot shot,
1580.

In a table of ordnance, given by Fosbrooke, as being a list of the guns used in the time of Elizabeth, and immediately preceding her, we find how little the calibres of iron guns have altered during the last two or three centuries, as these guns have all their antitypes among those of the present day.

Calibre, time
of Queen
Elizabeth.

The beginning of the seventeenth century was an important epoch in the history of artillery; and much attention was given to this branch of the military profession, by Henry IV., of France, Maurice, of Nassau, and Gustavus Adolphus of Sweden. The former of these distinguished leaders, introduced new and improved forms and kinds of missiles; such as tin cases, filled with steel bolts or darts; canvas cartridges, containing small balls, and hollow shot or shells, filled with combustible materials. Gustavus Adolphus, introduced really serviceable field guns, of a lighter construction than had hitherto been made use of, and he also adopted the use of cartridges, with shot attached, so that these pieces might be discharged eight times before the musket could be fired six. It is said that he chiefly owed his victory at Leipzig, in 1631, to guns made of leather and coiled rope, over a cylinder of copper or gun metal. On the whole, the artillery of Gustavus was admirably organized; and he was the first who appreciated the importance of causing artillery to act in concentrated masses, a principle, now so fully recognized by all artillerists.

Origin of
canister and
grape.

Improved
mode of load-
ing, by Gus-
tavus Adol-
phus.

Bombs were first used at sea, by the French, in the bombardment of Algiers, Oct. 28th, 1681, in the reign of Louis XIV.

Bombs at sea.

One of the largest cannon now existing is a brass one at Bejapoor, called "Moolik-i-Meidan," or "The Lord of the Plain." It was cast in commemoration of the capture of that place by the Emperor Alum Geer, in 1685. Its length is 14ft. 1in., diameter about 5ft. 8in., diameter of bore, 2ft. 4in., interior length of bore, 10ft.; length of chamber unknown; shape of gun nearly "cylindrical;" description of shot, *stone*. An iron shot for this gun, of proper size, would weigh 1600lbs. It is now lying in a dilapidated circular bastion on the left of the principal gateway of the city. The trunnions are broken off, and there is a ring on each side of it, as well as two Persian inscriptions on the top. It is placed on three heavy beams of wood, packed round with large stones. A number of *stone* shot, of 2ft. 2in. in diameter, are scattered about. This gun is said to be the heaviest piece of ordnance in the world. It weighs about forty-two tons. An Italian of Otranto, who served in the Mogul armies under the title of Renni Khan, had it in his park of artillery, and used it at several battles, occasionally firing sacks of copper coins out of it. (Plate 18, fig. 2.)

The largest
gun.

There is a remarkable gun near the palace of the Nawab of Moorshedabad, which measures 17ft. 8in. in length, 5ft. in circumference at the smallest part near the muzzle, while it is only 6in. in the diameter of the bore, and the foresight is at least four or five inches above the muzzle. After the battle of Khallissie, which was fought about 25 miles from here, it is supposed to have been buried under a tree. The tree, having grown since then, has forced the gun above the ground about three feet, where it now remains, partly encircled by the roots and trunk. It has no name;

Gun at Moor-
shedabad.

the natives call it "the gun in the tree." It is made of cast iron, and is evidently of Indian manufacture, having Hindostanee inscriptions engraved on it, but no date.

Size and expense of cannon, 1688.

Bishop Wilkins says, "These Gunpowder instruments are extremely expensive, as a whole cannon commonly weighs 8000lbs., requiring 90 men, or 16 horses, with a charge of 40lbs. of powder, and a ball weighing 64lbs.

Length and weight gradually reduced.

The length and diameter of cannon became gradually much reduced, experience having determined how much they might be diminished in weight without injury to their safety, or to the effects they were intended to produce.

Horse artillery by Frederick the Great.

Frederick the Great of Prussia made some improvements with regard to the calibre of field guns, and to him may be given the credit of the introduction of Horse Artillery.

Guns bored.

Guns, at this period, were cast hollow by means of a core, which was kept suspended in the centre of the mould, while the metal was being run in. Owing, however, to the great difficulty experienced in keeping this core in a perfectly true position, several artillerists deliberated whether guns, cast hollow or solid, had the preference, and investigations took place as to the possibility of boring the latter, the result of which was, that Maritz, who had a foundry at Geneva, informed the Court of France, in 1739, that he had discovered a method of boring guns and mortars which had been cast solid. He was at once invited to France, where, first at Lyons, and afterwards at Strasbourg, he secretly worked at boring pieces of ordnance, which, on trial, proved perfectly satisfactory.

Guns of ice.

In the year 1740, a curious experiment in artillery was made at St. Petersburg, where guns were cut out of solid ice, from which balls of the same substance were fired repeatedly, without bursting.

Improvements. Axle-trees. High limbers. Reduction of windage.

From this period, the science of artillery progressed rapidly, and various improvements were made in this arm of the service, such as the introduction of iron axle-trees, and high limbers for the carriages of field guns. The reduction of windage, (mainly owing to the invention of carronades), and the use of cartridges and elevating screws, which latter served to render the fire of artillery much more rapid and regular.

Rifled ordnance 1774.

The invention of rifled ordnance is claimed by a Dr. Lind and a Capt. A. Blair, late 69th regt. Experiments were made at Landguard Fort, 26th August, 1774, by which it was intended to prove that shot weighing 42lbs., in the shape of a pear, would do as much execution, fired out of an 18 pounder, with a third of the quantity of powder, as could be effected by round balls of the same weight, fired from a 42 pounder.

Perforated and fluted shot.

Sundry trials were also made with shot perforated through the centre, and spirally fluted on the surface, suggested by Professor Anderson, of Glasgow, in order to prevent the common aberration in the flight of shot.

Leadens projectiles.

There were different modes of charging the rifled guns; one was, after the powder was put in, to take a leaden bullet something larger than the bore of the gun, and grease it well; in ramming it down with an iron rammer hollow at one end, the spiral threads of the rifle entered and cut into the bullet, and caused it to turn round

in going down, and on being shot out, it would rotate on an axis coincident with its flight. Another mode was to charge them at the breech, where an opening for the reception of the powder and ball was afterwards closed up by a screw; but some barrels were screwed off at the breech-end to be charged, where they were made stronger than common.

Breech-loading Rifled cannon.

The adaptation of the rocket to the purposes of war, by Sir William Congreve, in 1806, introduced a new feature into the artillery of this and other countries.

Congreve's rockets.

Recently, at the suggestion of a Mr. Monk, of Woolwich Arsenal, a quantity of useless metal has been removed from before the trunnions, and the thickness increased considerably at the breech end, where alone it was wanted.

Mr. Monk's improvements.

The monster mortars recently constructed by Mr. Mallet, of separate compound hoops, must be regarded as a triumph of constructive skill. The shell is 30 inches in diameter, holding a bursting charge of 480 lbs., and weighing when charged $1\frac{1}{2}$ tons (3,360 lbs.). Value of shell charged, £25. Weight, without bed, 42 tons. Weight of bed, 8 tons. Total, 50 tons.

Mallet's monster mortar.

In 1846, two rifled cannon were invented, one by Major Cavalli, of the Sardinian Artillery; and the other by Baron Wahrendorff, a Swedish nobleman. Both of these were iron breech-loading guns, having two grooves in order to give the requisite rifle motion to their projectiles.

Cavalli's and Wahrendorff's

Experiments were carried on at Shoeburyness, in 1850, with these guns. The deviations were always in the direction of the rotation of the projectiles; but they were so variable in amount that no allowance could be made for them in laying the gun with respect to the object. The Cavalli gun became unserviceable after having fired four rounds, by the copper ring or bouche imbedded in the metal of the gun at the bottom of the bore being damaged. The Wahrendorff gun stood well, the wedge resisting more effectually the force of the discharge than that of the Cavalli gun.

Experiments to test.

Mr. Lancaster's novel invention of applying the rifle principle to cannon, may be described as "a two-grooved rifle in disguise," having a "gaining twist," the bore being an ellipse.

Lancaster's rifle gun.

The chief defect in the Lancaster gun is the liability of the projectile to jam in the bore, both in loading and firing, the former rendering the loading difficult, while the latter endangers the safety of the gun. In consequence of several of these guns bursting, and also from the anticipated large range with great precision not being obtained from them, the Lancaster guns were removed from the service after the Crimean war.

Defects of.

Sir W. Armstrong submitted a proposal for his breech-loading gun to the Duke of Newcastle, then Minister at War, towards the end of 1854; his proposal being accepted, and a gun accordingly constructed, it was submitted to numerous trials, both at Shoeburyness, and near Sir W. Armstrong's private factory at Newcastle. This gun is now made entirely of wrought iron, although the original one had a steel bore. It is a built-up gun, that is to say, it is composed of separate pieces, each piece being of such moderate size as to admit of being forged without risk of flaw or failure. By this mode of construction, great strength, and consequently, great light-

Sir W. Armstrong.

ness, are secured. The shell used combines the principle of the shrapnel and percussion shell, i.e., it may be made to explode either as it approaches the object, or as it strikes it. Moreover, it may be made to explode at the instant of leaving the gun, in which case, the pieces spread out like a fan, and produce the usual effect of grape or canister. Armstrong's guns are now (1860) being employed in China.

Whitworth.

Mr. Whitworth's rifled gun, with which experiments were lately made near Liverpool, is also a breech-loading piece, and of the following construction. The form of the bore is that of a hexagonal spiral, the corners of which are rounded off. The inclination of the spiral varies with the diameter of the bore, but is in all these guns very great, the projectiles being comparatively long.

French rifled ordnance.

Rifled ordnance were introduced into the French service just previous to the commencement of the late Italian war of 1859, and aiming at the greatest practical simplicity, the French government adopted only one nature of gun for field service, and one for siege purposes, both made of bronze. The French rifled cannon are muzzle loading, and those first introduced had two or three grooves, but the field pieces used in Italy had six grooves, their inclination being about one turn in 59 inches. A number of heavy cast-iron guns are rifled with two grooves, and have been placed on board French ships of war; and these, unless strengthened, could be used but with very small charges.

Advantages of rifled guns.

The advantages obtained by the successful employment of rifled guns—

Great accuracy of fire,
Long range,
Penetration,
Small charge,
Simplicity of equipment and ammunition,
Lightness of gun.

Classification of artillery.

Artillery may be classed under the several heads of field artillery (including artillery of position), siege artillery and artillery for the armament of garrisons, fortresses, and coast defences; its equipment is a combination of men, materiel, and horses necessary for these services.

Three kinds of guns.

All ordnance employed in the service, may be divided into three classes, viz., Guns, Mortars, and Howitzers.

Carronades discontinued.

Carronades may be considered obsolete, although a certain number are still supplied to the navy, and a few will be found mounted in some garrisons and coast batteries.

Classification of guns and their uses.

Guns are used for projecting shot and shell, horizontally or at very low angles, and as they are fired with large charges of powder, which are fixed for each nature of gun, very great strength and considerable weight are required in their construction. Guns are of two kinds, viz., (solid) shot guns, and shell guns. Some guns are also classed as heavy, medium, and light. Those generally employed for field service, are made of bronze or gun-metal; all guns of higher calibre, of cast-iron.

Mortars.

Mortars are short pieces of ordnance, used to throw shells at high angles (vertical fire), generally 45°, the charge varying with the range required; they are distinguished

by the diameters of their bores. Mortars are made of cast-iron or bronze; the former being principally intended for garrisons, battering trains, the navy, &c., and the latter, which are of small calibre, and very light, are chiefly employed in sieges.

Howitzers resemble guns in form, but are much shorter and lighter in proportion to their calibre, and are, consequently, fired with less charges of powder; shells and case are fired from them, but not solid shot.

Howitzers.

These pieces were originally introduced for the purpose of firing shells at low angles, and have constantly been found most useful both in the field and in siege operations during the wars of the last and present centuries. Since, however, the introduction of shell guns their utility has greatly decreased, for the shell gun possesses greater accuracy and range than the howitzer, those being in the present day of greater importance than small weight.

Use of
Howitzers.Superseded
by shell guns.

The Germans claim the invention of cannon for their countryman, Bartholdus Schwartz, who is said to have discovered it in 1336, but seeing that fire-arms first became prevalent in Europe in those countries which mixed with the Saracens, we are constrained to lean to the opinion that fire-arms were not re-invented in Europe, but introduced from the East.

Artillery from
the East.

This part of our subject might be much enlarged, but we have merely attempted to give heads of information, which can be pursued by those who desire to do so. We must now leave it, in order to treat upon that more immediately interesting to officers of infantry, viz., the history of portable fire-arms.

The following extract from an account of the furniture of the ship, called the "Harry Grace de Dieu," will give a good idea of the state of the ordnance at the time of Henry VIII. :—

Gonnes of Brasse.

Cannons,
Di. cannons,
Culveryns,
D. culveryns,
Sakers,
Cannon perers,
Fawcons,

Gonnes of Yron.

Port pecys,
Slyngs,
Di. slyngs,
Fowlers,
Baessys,
Toppe peces,
Hayle shotte pecys,

Hand gonnes complete.

Another account of ancient English ordnance in Queen Elizabeth's time, mentions the following :—

Bombards,
Bombardilles,
Cannon royal,
Cannon,
Cannon serpentine,
Bastard cannon,

Demi cannon,
Cannon petre,
Culverin,
Basilisk,
Demi culverin,
Bastard culverin,

Sacar,
Minion,
Faulcon,
Falconet,
Serpentine,
Rabinet.

ETYMOLOGIES.

CANNON.—From the Latin word *canna*, signifying a tube or cane.

HOWITZER.—From the German word *haubitze*, (derived from *haube*, top of a furnace), in French, *obus*, or *obusier*.

CARRONADE.—From *Carron Ironworks*, near Stirling, where it was invented in the year 1774.

BOMBARD.—From the Greek word *bombos*, or noise.

BOMBARDILLE.—A smaller kind of bombards.

BASILISK.—The name of a snake.

CULVERIN.—From the French *couleuvrine*, from *couleuvre*, a snake.

SAKER.—From *Saker*, or *Sacre*, a bird of the falcon species.

FALCON.—From the *bird* of that name.

CANNON PERERS.—*Stone-throwers*, from the French word *pierre*, a stone.

TOPPE PECES.—To be used in the tops, *i.e.*, the stands on the ship's masts.

NOTE.—The History of Artillery is mainly compiled from the following :—"Engines of War," by Wilkinson ; "Ancient Armour and Weapons in Europe," by John Hewitt ; "Military Antiquities," by F. Grose ; "Critical Inquiry into Ancient Armour," by Meyrick ; "Elementary Lectures on Artillery," by Major C. H. Owen and Capt. T. L. Dames, R.A. ; and "Our Engines of War," by Capt. Jarvis, M.P., Royal Artillery.

HISTORY OF PORTABLE FIRE-ARMS.

The earliest hand-guns differed in nothing but in size from the small cannon of the day: they consisted of a metal tube fixed in a straight stock of wood; the vent was at the top of the barrel; there was no lock of any kind. The barrels were short and made of iron or brass; they were occasionally furnished with moveable chambers. (Plate 19, fig. 1.)

Form of early hand-guns.

A specimen of hand-cannon of the early part of the reign of Henry VI., is made of iron, and furnished with trunnions, which from this specimen, appear to have been appropriated to small fire-arms before they were adopted for artillery. The breech is made of a separate piece and screwed on to the tube, on the further end of which is a sight. It was placed on a stock or club, and fired by hand with a match. (Plate 19, fig. 2.)

With trunnions.

Breech-loader

That hand-guns were invented, though but rarely appearing, in the fourteenth century, seems very probable from several cotemporary evidences. An inquisition taken in 1375, at Huntercombe, (a place belonging to the Abbey of Dorchester) and now preserved among the records at the Chapterhouse, Westminster, states that one Nicholas Huntercombe, with others, to the number of forty men, armed with "haubergeons, plates, bacenettes, cum aventayles, paletes, lanceis, scutis, arcubus, sagittis, balistis, *et gonnes*, venerunt ad Manerium de Huntercombe, and there made assault," &c. It appears very improbable that a body of men making a sudden attack upon an abbey manor-house, would be armed with any kind of "gonnes" except hand-guns.

Invented 14th century.

Mons. Mangeot states that "canons de fusil" were said to have been first invented in Bohemia, 1340, but that it is safer to fix the date at 1378, when mention is made of the "arquebuse à mèche" in Germany. In the year 1381, the inhabitants of Augsburg had thirty six arquebusiers, and in the following year they had portable fire-arms at the battle of Rosabecque. In 1383 the Lithuanians were acquainted with hand fire-arms, and used them at the siege of Froski. All these arms had straight stocks.

Bohemia 1340

Lithuanians 1383.

In the excavations of the Castle of Tannenberg, dismantled in 1399, there was found a hand-gun of brass, with part of the wooden stock remaining, and the iron rammer belonging to it.

An early mention of the hand-gun is that of Juvenal des Ursins, who tells us, under the year 1414, that they were used at the siege of Arras.

Billius, a learned and noble Milanese, who lived at the time, says that hand-guns

Siege of Lucca 1430.

were first used at the siege of Lucca, in 1430. The Florentines were provided with artillery, which, by the force of gunpowder, discharged large stones, but the Luccese perceiving that they did very little execution, came at last to despise them, and every day renewed their sallies to the great slaughter of their enemies, by the help of *small fire-arms*, to which the Florentines were strangers, and which before this time were not known in Italy. Billius explains this by saying, "That besides darts and balistas for arrows, they invented a new kind of weapon. They carried in their hand a club, a cubit and a half long, to which were affixed iron barrels. These they filled with sulphur and nitre, and by the power of fire, iron balls were thus ejected." (Plate 19, fig. 1 and 10).

Said to have
been invented
in Italy.

Scorpion. About this time the scorpion (afterwards a piece of ordnance) was a tube for firing gunpowder, held in the hand, and called by the English, hand-cannon, and also hand-culverines.

Made of brass. From a roll of purchases for Holy Island 1446 is,—“bought 11 hand gunnes de ere,” from whence we learn that they were made of brass.

Edward IV. Hand-guns, or hand-cannons were used in the early part of the reign of Edward IV., and towards the close of it, we learn from Philip de Comines, that the harquebus was invented; this seems to have been an improvement on the hand-gun. The Latin word used for this weapon was arcusbusus, evidently derived from the

Harquebus
invented.

Stock, &c.,
from cross-
bow.

Match-lock.
1478.

Italian, arca-bouza, a bow with a tube or hole; to that people, therefore, are we to ascribe the application of the stock and trigger in imitation of the cross-bow. Hitherto the match had been applied by the hand to the touch-hole, but the trigger of the arbalest suggested the idea of one to catch into a cock, which having a slit in it, might hold the match, and by the motion of the trigger be brought down on a pan which held the priming, the touch-hole being no longer at the top but at the side. (Plate 19, fig. 9).

Hand-gun im-
provements.

The hand-gun was *cast* in brass, and, as a tube, was of greater length than the hand cannon; a flat piece of brass, made to turn upon a pin, covered the pan which contained the powder; it had also a piece of brass fixed on the breech, and perforated to ensure the aim.

Sighted.

Hand-guns in
England 1491

The first introduction of hand-guns into England, we find, was soon after their invention in Italy; in the year 1471, King Edward IV., landed at Ravenspurg, in Yorkshire, and brought with him, among other forces, three hundred Flemings, armed with “hange-gunnes.” In 1474, he directed “all the bombs, cannon, culverines, fowlers, surpentine, and all other cannon whatsoever, as also powder, sulphur, salt-petre, stones, iron, lead and other materials, fit and necessary for the same cannon, wherever found, to be taken and provided for his use, paying a reasonable price for the same.”

Made in En-
gland, 1474.

Harquebu-
siers.
Morat 1476.

Arquebusiers, or harquebusiers, are mentioned as troops, by Philip de Comines, in these words, where he speaks of the battle of Morat, fought on the 22nd of June, 1476. “The said towns had in their army, as some that were in the battle informed me, 35,000 men, whereof fower thousand were horsemen, the rest footmen, well chosen and well armed, that is to say, 10,000 pikes, 10,000 halberds, and 10,000 harquebusiers.”

Hitherto the harquebuss had only a straight stock, but now it had a wide butt end, which might be placed against the right breast, and thus held more steadily. Many ancient pieces were held to the breast instead of the shoulder, which will account for their being so short in the stock. A notch was made in the butt for the thumb of the right hand, in order to hold the piece more firmly. When the butt was bent down or hooked as it was at a later period, it was called, from the German word Hake, a hackbutt, haggebut or hagbut, the small sort being denominated demi-hags.

Philip de Commines mentions that there were at the battle of Fourniée, in 1495, German harquebusiers, on foot and on horseback. (Plate 19, fig. 6.)

The small arms in the time of Henry VIII., were hand-guns, haguebuts, demi-hagues and the pistol, and it was enacted, "that no hand-gun should be used, of less than one yard, gun and stock included, and the haguebut was not to be under three-quarters of a yard." The demi-hagues were still smaller, and gave occasion for the origin of pistols, which were invented in the latter part of this reign, at Pistoria in Tuscany. The dag, dagger, or tache, differed from the pistol merely in the shape of its handle.

The match was a constant source of trouble to the soldier, both from the difficulty of keeping it alight in bad weather, and from the length of time it sometimes took to ignite the charge. It was therefore not without justice that many persons clamoured about this time against the introduction of fire-arms. They contended that upon no point, save that of penetration, was the harquebuss superior or equal to the long-bow; its great weight 16 or 18lbs. (seldom less than 12lbs.) obliged it to be supported by a rest, which had a kind of fork to receive the musket, and at the bottom a sharp metal spike, to strike into the ground; (Plate 19, fig. 5, 7, and 8). When the harquebuss was shouldered the rest was carried in the right hand, and subsequently hung upon it, by means of a string or loop. The difficulty of keeping the powder and match dry, the time taken to load, and its comparative inaccuracy, rendered it of low reputation. Nevertheless it held its ground, and the next improvement was the wheel-lock, by which a more instantaneous ignition of the charge was secured; it was invented at Nuremberg, 1517. It consisted of a little solid wheel of steel, fixed against the plate of the lock of the harquebuss or pistol; it had an axis that pierced it in its centre; at the interior end of this axis which went into the lock, a chain was fastened, which twisted round it on the wheel being turned, and bent the spring by which it was held; to bend this spring a key was made use of, into which the exterior end of the axis was inserted. By turning this key from left to right, the wheel was made to revolve, and by this movement a little slider of copper, which covered the pan with the priming, retired from over it; and by the same movement the cock, armed with a flint like the cock of a fusil, was in a state to be discharged on pulling the trigger with the finger; the cock then falling on the wheel, produced fire, and communicated it to the priming. The wheel-lock was first used at the siege of Parma, 1521, and was brought to England 1530. It was however complicated and difficult to repair, for which reason it could not always be depended upon, as is proved by some fire-arms of this description at the Tower, which are made with a serpentine, as well as with a wheel, both acted upon by the same trigger.

Improve-
ments.

Held to breast

Bent butt.

Hackbutt.

Mounted Har-
quebussiers.

Arms in time
of Henry VIII

Inconveni-
ences of match

Objections to
fire-arms.

Rest.

Wheel-lock,
1517.

Used at Par-
ma, 1521.

In England,
1530.

Serpentine
and wheel.

Musket in
Spain.

At Pavia,
1525.

Low Coun-
tries, 1567.

The inconsiderable execution done by pieces of small calibre probably caused the introduction of the muskets or mosquet, which originated in Spain about the time of Francis I. They are said to have been first employed extensively at the battle of Pavia, 1525; but, if we believe Brantome, it was the Duke d'Alva who first brought them into use in the armies, when during the reign of Philip II., he went to take upon him the government of the Low Countries in the year 1567; but that only means, he brought them more into fashion than they were till that time, and that till then they were rarely used, at least in the field, on account of their cumbrous nature. A Spanish army of 10,000 men sailed from Carthagena, 27th April, 1567, *en route* for the Netherlands, to do which they had to cross the Alps. It was a picked body of troops, of whom about 1,300 were cavalry. The Duke d'Alva formed them into three divisions, and dispensed with artillery, not wishing to embarrass his movements. Each company of foot was flanked by a body of soldiers, carrying heavy muskets with rests attached to them.

Lephanto,
1571.

At the battle of Lephanto 1571, fought between the Venetians and Turks, it is stated by the historian, that one chief reason why so few Christians were killed in comparison, was because the Turks used for the most part bows and arrows, whereas the former were supplied with muskets.

Caliver.

A lighter kind of musket was called a caliver or calliver, which was only a corruption of calibre, denoting that they were all of one guage, as the original harquebuses were not of any particular length or bore; the caliver was fired without a rest.

Dimensions,
1621.

Sir Thomas Kellie in his "Art Militaire," published in 1621, says, "The barrel of a musket should be four feet in length, the bore capable of receiving bullets twelve whereof weigh a pound, previous to this some had carried ten to the pound."

Hand-mortar,
1594.

The hand-mortar for throwing grenades are said to have been first used in 1594, and gave origin at a later date to the troops thence denominated, *grenadiers*. They appear to have been fired from the shoulder. (Plate 19, fig. 3.) In the reign of James II., a flint-lock-musket was adapted to fire grenades from the butt, the small of which was made to resemble a chambered mortar; the heel of the butt formed a cover, which opened with a spring on a hinge; the priming was put into the usual pan, and a small piece of metal moved so as to open a communication with the powder in the chamber. A rest was formed by a slender iron rod, about three feet long, and when not required let into the stock, in the place usually occupied by the ramrod, and turning upon a pivot placed a few inches in front of the guard-brass. The scouring rod is run through metal loops on one side of the stock. Afterwards grenades were thrown by hand, the musket being slung over the soldier's back, and more recently experiments were made with an iron tube about four inches long, placed on the muzzle in the same manner as the bayonets.

From butt of
musket.

By hand.

From muzzle.

Match-locks
and rest,
James I.

In the time of James I., part of the infantry were armed with calivers or muskets and rests, both of which were fired with match-locks, the soldier carrying the match lighted at both ends.

Trickerlock,
1629.

"A match trickerlock compleat," occurs in a schedule of 1629. This was the

adoption of what is now called a hair trigger, which was added to the former one, and gives a more instantaneous discharge. A tricker wheel lock of Charles I., a tricker match-lock of Charles II., and a tricker fire-lock of James II., are preserved in Sir S. Meyrick's collection.

The Earl of Albermarle in 1646, says, "It is very fit likewise that you have in each company six good fowling pieces, of such a length that the soldier may well be able to take aim and shoot off at ease; being placed six on each flank of a division of foot to skirmish with an enemy. These soldiers ought to have command, when they come within distance, that they shoot at officers only." We have here plainly the origin of riflemen.

Fowling
pieces.

Each musketeer formerly carried a tin tube, pierced full of holes, to contain the match, and prevent his being discovered; in wet weather it was necessary to carry it in the crown of his cap, to prevent it from being extinguished. One of the earliest attempts to overcome this difficulty is in the Arsenal, at Dresden, where there is an old *buchse*, with a piece of pyrites fixed opposite to the touch-hole, and which requires to be rubbed with a file, chained to it, until sparks are elicited sufficient to fire the powder.

Tin tube for
match.

First fire-lock

The next improvement upon the wheel-lock was the snaphaunce; a flat piece of steel, furrowed in imitation of the wheel, was placed on a steel post, which being screwed beyond the pan, was made moveable; the pan had a cover which required to be pushed off by the thumb, and the furrowed piece being then brought to stand over it, on pulling the trigger, the flint, which was substituted for pyrites, struck against it, and gave the spark.

Snaphaunce.

The next step in the improvement of the musket was the introduction of the flint-lock, now so well known, that I need not enter into the details of its mechanism.

Flint lock.

It was used in France as early as 1630, but was not employed in the army until 1670 or 80, when it took the name of "fusil." It was not employed in England until about 1677, and its advantages over the matchlock are thus described in a work addressed to King Charles II., in 1677, by the Earl of Orrery:—"First it is "exceedingly more ready, for with the fire-lock you have only to cock, and you are "prepared to shoot, but with the matchlock, you have several motions, besides if you "fire not the matchlock as soon as you have blown your match, (which often, "particularly in hedgefights and sieges, you cannot do) you must a second time blow "your match. The match is very dangerous, either when bandoliers are used, or "when soldiers run hastily in fight to the budge barrel, to refill their bandoliers. I "have often seen sad instances thereof. Marching in the nights to avoid an enemy "or to surprise one, or to assault a fortress, the matches often discover you, whereby "you suffer much, and he obtains much. In wet weather, the rain deads the powder "and the match too, and the wind sometimes blows away the powder, ere the match "can touch the pan; nay, in very high winds, I have seen the sparks blown from the "match, fire the musket ere the soldier meant it, and either thereby lose his shot, "or kill some one before him. Whereas in the firelock, the motion is so sudden,

In France,
1630.
In England,
1677.

Earl Orrery's
opinion.

“that what makes the cock fall on the hammer, strikes the fire and opens the pan at once. Lastly, the quantity of match does much add to the baggage, it naturally draws the moisture of the air, which makes it less fit, and if you march without close waggons, it is the more exposed, and without being dried again in ovens is but of half the use which otherwise it would be of, and which is full as bad as the skeans you give the corporals, and the sinks you give the private soldiers, being rendered useless if damp; nothing of all which can be said of the flint, but much of it to the contrary.”

Bows to be replaced by muskets, 1596

In a proclamation of Queen Elizabeth dated 1596, it is stated, “You shall bring with you all such furniture and weapon for footmen as you stand charged withall by statute, or have formerly shewed at other musters heretofore, changinge your billes into pikes, and your bowes into muskettes accordinge to our sayde former letters.”

Muskets with two locks.

In France, as late as 1702, when the flint had wholly superseded the pyrites, and the structure differed very little from our present musket-locks, an additional cock was attached to the end of the lock-plate, and a sliding cover placed over a hole in the hammer-seat, for the purpose of lighting the powder by a match, if the flint failed. The match was therefore from its simplicity, preferred from all others for a considerable period, and is still used by the Chinese, Tartars, Persians, and Turks, in some provinces either wholly, or partially. The match itself was made of cotton or hemp, spun slack, and boiled in a strong solution of saltpetre, or in the lees of wine.

Match-lock preferred.

Match made of.

Iron ramrod 1740.

In the time of Frederick the Great, (1740 to 1786), the invention of the iron ramrod by the Prince of Dessau, trifling matter as it seems, doubled the value of the fire of infantry. Prior to this the rammer had been made of wood, and was called the scouring stick.

Dimensions, &c. of English musket, in 1800. Charge.

At the commencement of this (19th) century, the weight of the English musket and bayonet was 11lbs. 4ozs., bayonet 1lb. 2ozs., length of barrel 3ft. 3-in., bore 753-in., bullets 16 to the pound. Charges of powder 6 drs., F.G. Every soldier was furnished with three flints for 60 rounds. Originally it had been necessary to put the priming into the pan from a flask, containing a finer grained powder, called “Serpentine powder,” but in the early flint-lock musket this was rendered unnecessary, as in loading, a portion of the charge passed through the communication hole into the pan, where it was prevented from escaping by the hammer. Latterly a portion of the cartridge was bitten off, and the pan filled with priming before loading.

Priming, 1st. mode.

Priming, 2nd mode.

Objections to flint-lock.

Priming by detonation, 1807.

The objections to the flint-lock were, that it did not entirely preserve the priming from wet. Sometimes the flint failed to ignite the charge, and it was necessary to change it frequently. Owing to these imperfections, in 1807, the Rev. Mr. Forsyth obtained a patent for priming with fulminating powder. The composition consisted of sulphate of potash, sulphur, and charcoal, and exploded when struck by any metal or hard substance. This composition was considered too corrosive, but was subsequently improved, and finally applied to the musket, in the form of the present percussion cap, which consists of chlorate of potash, three parts; fulminating mercury two parts; and ground glass one part. The experiments for Mr. Forsyth’s invention,

Experiments, 1834.

commenced in 1834. Six thousand rounds were fired from each description of arm, and the experiments conducted in all weathers, six of each kind of arm being used. The result proved exceedingly favourable to the percussion principle, and may be briefly summed up as follows:—1st, out of 600 rounds from the flint-lock, there were 922 missfires, being 1 in $6\frac{1}{2}$, whereas in the percussion musket there were only 36 misses in 6,000 rounds, or 1 in 166. With the flint-lock there were 3,680 hits out of the 6,000, and with the percussion 4,047 hits, being 7 per cent. in favour of the latter. To fire 100 rounds with the flint required 32 minutes 31 seconds, whereas the percussion occupied only 30 minutes 24 seconds. Another advantage of the percussion musket, was that it was capped *after* being loaded. Hitherto a certain amount of powder had been allowed for priming, but as this vestige of the hand-gun could be dispensed with, a reduction of charge could be made; a total reduction however was made from 6 to $4\frac{1}{2}$ drs., which caused a diminution of recoil. The $4\frac{1}{2}$ drs. then recommended was known to be more than was necessary for the projection of the bullet, but an extra $\frac{1}{2}$ dr. was retained to allow for the effect of damp or waste on service. In the course of these experiments, it was found that the considerable force required to pull the trigger might be advantageously reduced, and that increased accuracy would ensue, therefore the pull of the trigger was lessened to 7lbs.

Advantages
of percussion.

Reduced
charge.

Reduced pull
of trigger.

The advantages of the percussion system having been satisfactorily shown, it was decided to convert a portion of the old flint-locks into percussions, and to establish a new model percussion musket for the English army.

New model
musket.

The following anecdote illustrates the weak points of the flint-lock. During the Chinese war, a company of the 37th Madras Native Infantry had been detached to the left, when, the evening closing, the order was given to rejoin, and the whole were to retire upon Canton, and just as it was being carried into execution, a tremendous storm of wind and rain arose, making the air so dark, that no one could see 20 yards. The detached company retired sounding bugles and beating drums, which were drowned by the tempest, and they could not find the battalion. In a few minutes the enemy got between this company and the retreating force. The muskets would not go off, and several attempts of the enemy to close were with difficulty repulsed with the bayonet. In the meantime, the enemy contrived to fire off their own matchlocks, and some of the sepoys' muskets of men who had dropped in the retreat, by applying matches to them. The square into which the company was formed, was thus being diminished, while the only return that could be made, was an occasional shot from a solitary musket, which the three officers of the company managed to clean out, under cover of great coats held over the muzzle. A company of Marines was dispatched for the 37th party, armed with percussion muskets, scarcely one of which missed at the first fire, and a few volleys sufficed to clear the way, and both detachments reached the camp in safety, with but little loss. This happened in the early part of 1841.

Percussion at
Canton.

After a "hang-fire" of about 200 years, a new pattern percussion musket was issued in 1842. Its weight was greater than that of the old flint-lock, being with the bayonet about 11-lbs., 6-oz., bayonet 1-lb., 0-oz., 8-drs., bore .753, barrel 3-ft. 3-in., length, with bayonet

Percussion
introduced,
1842.

Sighted for
150 yards.

6 feet, length without 4-ft. $6\frac{3}{4}$ -in., a block sight for 150 yards, and a percussion lock. For many years prior to 1839 no sight at all was thought necessary for the musket, the bayonet stud being sufficient, but which was totally obscured when fired with fixed bayonets. This arm continued as the approved weapon for our infantry without improvement until 1851, when the Minié rifle was partially introduced.

Comparison
with foreign
muskets.

The English musket (1842) differed from all those in use on the Continent, in having, 1st, the least accuracy, 2nd, reduced range, 3rd, heavier, 4th, shorter, 5th, larger bore, 6th, greater windage, 7th, double the charge of powder, 8th, the greatest recoil, and 9th, the most expensive! *i. e.*, as compared with those of France and Belgium, Prussia, Austria, or even with the old Sikh matchlock!! And yet a "stand up fight" was stoutly maintained for this most inefficient arm, by many military men, as may be seen from the following extract from a note in Part II., Vol. II., of the "Aide Memoire to the military sciences:"—"Erroneous ideas prevail as to the precise wants "of the service with regard to the musket, and its proper qualities and utility in the "field, as well as much exaggeration as to the defects of the new percussion musket "of 1842, for the infantry of the line. It is stated that it is too heavy and of imper- "fect construction. Some prefer the French pattern, and others would lessen the "weight and calibre still more, reducing also the windage: as, however, the new regu- "lation has brought into use some hundreds of thousands of new muskets, and has been "approved by the highest authorities, some considerations are necessary before a "radical change can be effected beyond range and a nice accuracy of fire. 1st, "What are the essentials for a musket for the infantry of the line? 2nd, The appli- "cation of the musket to the infantry soldier. It is evident that the most essential "points are strength, and facility of pouring into your enemies' ranks a powerful fire. "Troops do not halt to play at long bowls; a field of battle presents a series of move- "ments for the purpose of outflanking or closing in upon your enemy, and when "within two hundred yards, to deliver your fire with effect. Firing at 500 or 600 "yards is the business of artillery, and, therefore, to fire at 300 or 400 yards is "a misapplication of the musket, a loss of time, a waste of ammunition, and tends to "make men unsteady in the ranks."

Brown Bess
advocated.

Brown Bess
tried at
Chatham.

The shooting powers of the musket (1842) are stated in the report on Experimental Musketry firing carried on by Captain (now Lieut.-Colonel) McKerlie, Royal Engineers, at Chatham, in 1846, which concludes as follows: "It appears by these "experiments, that as a general rule, musketry fire should never be opened beyond "150 yards, and certainly not exceeding 200 yards. At this distance, half the num- "ber of shots missed a target 11-ft. 6-in., and at 150 yards a very large proportion "also missed. At 75 and 100 yards every shot struck the target, only 2-ft. wide, and "had the deviation increased simply as the distance every shot ought to have struck "the target 6-ft. wide at 200 yards, instead of this, however, some were observed to "pass several yards to the right and left, some to fall 30 yards short, and others to "pass as much beyond, and this deviation increased in a still greater degree as the "range increased. It is only then under peculiar circumstances, such as when it may "be desirable to bring a fire on Field Artillery when there are no other means of

"replying to it, that it ought ever to be thought of using the musket at such distances "as 400 yards." In fact, it has been stated that the probability of hitting one man with a musket ball at 500 yards would be as one farthing to the National Debt! On a recent occasion, at the Cape, 80,000 rounds were fired to kill 25 men!! To put a man "*hors de combat*" requires his weight in lead, and six times his weight in iron!!!

Our musket cost £3, the French and Belgian £1 8s. 6½d. In foreign arms the barrel is fastened to the stock by bands, binding the two together, and thus adding greatly to their strength. This mode, although acknowledged to be infinitely superior for military purposes, by our Inspector of small arms, was condemned as unsightly!! The French musket, although three inches longer, is beautifully poised, being lightened forward. Our bore being larger was considered an advantage, as their balls could be fired out of our barrels, while our balls could not out of their muskets. It was generally thought that the greater weight of the English ball produced an increased range and momentum, but this was counteracted by the excess of windage.

Merits of
"Brown Bess"
illustrated.

Price.

Fastened by
bands.

Bands
unsightly!!

Supposed
profit of large
bore.

In former days small arms were made of various shapes and devices, and also combined with other weapons of attack and defence.

Various forms
of early fire-
arms.

There is in the arsenal at Venice a matchlock containing twenty barrels, ten gun barrels, about 2½ feet long, and ten pistol barrels half that length. The match exploded a gun and pistol barrel together.

The Chinese of the present day make use of a species of matchlock revolvers, and also of another matchlock, consisting of several barrels, placed on a common stock, diverging from each other, and fired simultaneously. (Plate 4, fig. 4 and 5.)

Soon after the invention of fire-arms, the boss, or spike, issuing from the centre of the targets or shields, was superseded by one or more short barrels, fired by a matchlock, and having an aperture covered with a grating above, for the purpose of taking aim. These barrels were loaded at the breech, the charge being put into an iron tube, or short barrel, which was pushed in at the end, and retained there by shutting down a lid or spring.

Shield fire-
arms.

Breech-
loaders.

There were cross-bows, which combined a pistol and cross-bow, the wheel-lock being placed about the centre of the handle on one side, whilst on the other was the string of the bow, and the windlass for drawing it up.

Cross-bow
and pistol
united.

Pistols were frequently introduced into the butt-end of pikes, and also, in the reign of Edward VI., in the handle of the battle-axe, the spiked club, the martlet, and other weapons, even the dagger.

Pike and
pistol.

In the time of Charles I. there were esclopette carbines, made with the butt to double back on a hinge, in order to get them into a holster; and a little later the butt was lengthened by drawing out the steel cap which formed its cover, now called heel plate.

Carabines
with joint.

Heel plate to
draw out.

In the reign of Charles I. there were also revolvers, with eight chambers to hold the charges; and in the time of Cromwell and Charles II. we find self-loading and self-priming guns. Pistols were made both double-barrelled and revolving.

Revolvers in
Charles I.
Double-bar-
relled pistols.

Arrows fired
out of mus-
kets, 1591.

In Sir Richard Hawkins' account of his voyage in the South Sea, 1591, mention is made of his shooting arrows from muskets with great success at shipping: "for the "upper works of their ships being musket proof, they passed through both sides with "facilitie, and wrought extraordinary disasters, which caused admiration to see them- "selves wounded with small shot when they thought themselves secure." These wooden arrows were called sprites or sprights. Lord Verulam says, "it is certain "that we had in use at one time for sea fight short arrows which they call sprights, "without any other head save wood sharpened, which were discharged out of "muskets, and would pierce through the sides of ships, when a bullet would not "pierce."

Sprites re-
quired wads.

Sir Richard Hawkins informs us, that in a discourse which he held with the Spanish General, Michael Angell, the latter demanded, "for what purpose served the "little short arrowes which we had in our shippe, and those in great quantity. I "satisfied him that they were for our muskets. Hereof they prooved to profit them- "selves after; but for that they wanted the tampkins, which are first to be driven "home, before the arrow be put in, and as they understood not the secret, they rejected "them as uncertaine, and therefore not to be used; but of all the shot used now "adayes, for the annoying of an ennemie in fight by sea, few are of greater moment "for many respects, which I hold not convenient to treat of in public."

Thus it appears that bullets of metal, have been fired out of bows and slings, stone balls out of guns, and arrows from muskets.

The following are the names of different descriptions of small arms, viz:—

Hand-cannon	Musketoone	Hand-mortar
Hand-gun	Hague	Blunderbuss
Arquebus	Demi-hague	Musket
Caliver	Esclopette	Pistol
Petronel	Currier	Dag
Scorpion	Fusil	Tack
Dragon		

THE BAYONET.

It was common with archers to place a long pointed stake in the ground to protect themselves against cavalry. On the arquebus replacing the bow the same practice was continued.

Pointed stake

From the earliest ages it had been customary to arm some of the infantry with pikes, and in the middle ages when cavalry was so much employed in armies, it was found impossible to dispense with this weapon; for some time after the introduction of fire-arms, only a portion of the infantry were armed with them, and the remainder were pikemen. The proportion of each varied at different times, from one half to two thirds, but as the proportion of musketeers increased it became necessary to contrive some method, by which they could defend themselves.

Pike.

In the latter part of the reign of James I., some attempts were made to convert the musketeer's rest into a defence against cavalry. *Marlets-de-fer* and small pole-axes had a touch enclosed in them, which by touching a spring opened a small valve and sprung out. The musket rest, instead of having a wooden shaft, was now made of a thin tube of iron, like these pole-axes covered with leather, and armed with the touch. Rests thus armed were said to contain Swedish or Swines' feathers. It was found however that the musketeer could not do his duty when armed with musket, sword, and rest, (especially if he had a Swedish feather to manage with them) which led to the abandonment of the rest during the Protectorate.

Marlets-de-fer
with touch.

Rest, with
touch.

Swines'
feathers.

To remedy the inconvenience of a Musketeer being compelled to draw his sword and defend himself after the discharge of his piece, and to render him more competent to act against the pikemen, a long thin rapier blade fixed into a handle, and carried in a sheath called a Swine's feather, was drawn out of its scabbard, and fixed into the muzzle of his gun, which gave him a weapon of great length. (Plate 19, fig. 11.). And this dagger or sword, stuck into the muzzle of the gun, gave origin to the bayonet, which was first made at Bayonne, and introduced into the French army in 1671.

Sword stuck
in muzzle.

Bayonets in
France, 1671.

Swords in general were left off in the battalion companies ever since the year 1745, and about 1762 by the grenadiers. As a still further improvement the bayonet was made to fit on to the side of the barrel, so as to leave it clear. An early application of the improved bayonet took place in the campaigns of William III., in Flanders. Three French regiments thus armed, marched with fixed bayonets, and one of them against the 25th regiment. Lieut-Colonel Maxwell ordered his men to

Swords dis-
continued,
1745.
Improved
bayonet.

Bayonet in
Flanders,
William III.

Bayonet at
Killcrankie.

screw their bayonets into their muzzles to receive them; but to his great surprise when they came within the proper distance, the French threw in such a heavy fire, as for the moment to stagger his people, who by no means expected such a greeting, not conscious how it was possible to fire with fixed bayonets. Macaulay in the 3rd volume of his History, states "That at the battle of Killcrankie, the King's army being "drawn up in position, the Highlanders advanced to the attack, and immediately after "having delivered their fire, threw away their muskets and rushed on to the charge "with Claymores. It took the regular musketeer two or three minutes to alter his "missile weapon into one with which he could encounter an enemy hand to hand, "and during this time the battle of Killcrankie had been decided." Mackay therefore ordered all his bayonets to be so made that they might be screwed upon the barrel.

Bayonets,
Marsaglia,
1693, and
Spiers, 1703.
Pike
abolished,
1703.
Earl Orrery in
favour of pike
versus mus-
ket, 1677.

Bayonets were employed by Marshal Latinat at the battle of Marsaglia, when the slaughter was immense. Also at the battle of Spiers, in 1703. Thus improved, the bayonet came into general use, and the pike was abolished in France by Royal Ordinance 1703, with the advice of Marshal Vauban. Before the introduction of the improved bayonet, Lord Orrery, in 1677, thus speaks in favour of the pike:—"But "what need I more say of the usefulness of the pike above the musket, than that all "persons of quality carry the pike which they would not do unless it had adjudgedly "the honour to be the noblest weapon, since the bravest choose and fight with it. I "wish our companies consisted of fewer shots and more pikes, for they are not only "always in readiness but need no ammunition, which cannot be said of the musket "which requires powder, bullet, and match, and in wet or windy weather often dis- "appoints the service."

M. Mallet,
pike versus
musket, 1684.

Mons. Mallet in his "Travaux de Mars," speaks lightly of the "masquitairey," without pikemen; he says, "A horse wounded by a fire-arm is only more animated, "but when he finds himself pierced by a pike, all the spurs in the world will not make "him advance."

Gen. Loyd,
pike versus
bayonet, 1766.

Even so recently as about ninety-two years ago, and ninety-five years after the introduction of the improved bayonet, General Loyd in his history of the war in Germany, recommends the abandonment of the system of arming the whole of the infantry with fire-arms, "which he says are useful only in *defensive* warfare, and even "then not more than one shot in four hundred takes effect." For many years after pikes were discontinued by our infantry, the officers carried a short one, and the sergeants only gave up their halberts within the last thirty years. The soldiers of artillery when in Holland under the late Duke of York, carried short pikes for the defence of their field guns.

Pike recently
discontinued.

ACCOUTREMENTS AND AMMUNITION.

Armament of
infantry sol-
dier.
Bandolier.

Besides his matchlock, the soldier carried a powder horn or flask, a ball bag, slow match, a rest, and a sword. The two last changed for a bayonet. In order to accelerate the loading, a large leather belt, called bandolier, was worn over the

shoulder. To this were hung twelve wooden cases, each of which contained one charge, with a case of finer powder for priming, and at the lower end a bag for balls. This system was soon found to be inconvenient, as the cases were apt to get entangled in passing through woods, &c. It was therefore abandoned in France in 1684, and the flask resumed. Sir James Turner, speaking of the pistol, says, "All horsemen "should always have the charges of their pistols ready in patrons, the powder made "up compactly in paper, and the ball tied to it with a piece of pack thread." In this description we have evidently the cartridge, though not expressed by name. It is a curious fact that these were first confined to the cavalry, and that the general adoption of the cartridge was not earlier than the common use of the modern firelock. The Patron was an upright semi-cylindrical box of steel, with a cover moving on a hinge, filled with a block of wood with five perforations, to hold as many pistol cartridges.

Bandolier
abandoned in
France, 1684.

Flask
resumed.
Patrons.
Cartridges.

The Earl of Orrery, in 1677, writes, "I am, on long experience, an enemy to "bandoliers, but a great approver of boxes of cartridges for them, as by biting off "the bottom of the cartridge, you charge your musket for service with one ramming. "I would have these boxes of tin, because they are not so apt to break as the "wooden ones are, and do not, in wet weather, or lying in the tents, relax. Besides, "I have often seen much prejudice in the use of bandoliers, which are often apt to "take fire. They commonly wound, and often kill he that wears them, and those "near him, for likely if one take fire, all the rest do in that collar. They often "tangle when they have fired, and are falling off by the flanks of the files of the "intervals to get into the rear to load again. Their rattling in the night often "discovers the designs; and if the weather be windy, their rattling also often hinders "the soldier from hearing, and, consequently, obeying the word of command. "Whereas the cartridge boxes exempt those who use them from all these dangers "and prejudices. They enable the soldier to fire more expeditiously. They are also "usually worn about the waist of the soldier, the skirts of whose doublet and whose "coat doubly defend them from all rain, that does not pierce both, and being worn "close to his body, the heat thereof keeps the powder dryer. Besides all this, who- "ever loads his musket with cartridges, is sure the bullet will not drop out, though "he takes his aim under breast high; whereas those soldiers on service who take the "bullets out of their mouths, which is the nimblest way, or out of their pouches, "seldom put any paper, tow, or grass, to ram the bullet in, whereby if they fire "above breast high the bullet passes over the head of the enemy, and if they aim low "the bullet drops out, ere the musket is fired, and it is to this that I attribute the "little execution I have seen musketeers do in time of fight, though they fired at "great battalions, and those also reasonably near."

Earl of Orrery in favour
of pouches.

The preceding article on Portable Fire-Arms is principally compiled from "Military Antiquities," by Francis Grose; "Ancient Armour and Weapons of War," by John Hewitt; "Engraved Illustrations of Ancient Armour," by Joseph Skelton, F.S.A.; "A Critical Enquiry into Ancient Armour," by Sir R. S. Meyrick, Knt.; and "Deane's Manual of Fire-arms."

HISTORY OF THE RIFLE.

Invention of
the rifle.

1466.

Rifles at Leip-
sic, 1498.

Rifles used
first for
amusement.

Rifles used in
war.

Landgrave of
Hesse, 1631.

Elector Max-
imilian, 1645.

Frederick
William of
Prussia, 1674.

Frederick the
Great in
Seven Years'
War.
By Austrians
ditto.

Rifles in
France, 1674.

Rifles in En-
glish Life
Guards.

Rifles in
Sweden, 1691.

Experiments
in England,
1776.

We shall now direct our attention to the rifle,—its invention is ascribed to Gaspard Zollner, of Vienna, towards the end of the fifteenth century.

The first society for firing with the arquebuss was founded at Bâle, in Switzerland.

In the practice of firing at a mark, at Leipsic, 1498, the greater part of the Sharpshooters or Marksmen, were armed with the Rifles.

At first, Rifle arms were used only for amusement, and sometimes for the defence of places, but very rarely as weapons of war in the field.

Their employment in a campaign only dates from a little before the middle of the seventeenth century.

In 1631, the Landgrave William of Hesse had three companies of Chasseurs, armed with rifles.

In 1645, the Elector Maximilian of Bavaria formed three regiments of Chasseurs, armed with rifles which he intended to employ principally in the minor operations of war.

In 1647, Frederick William of Prussia, in his campaign on the Rhine, distributed in each company of infantry, some light infantry and Riflemen.

Frederick the Great, in order to counterbalance the Austrian Light Troops, more particularly the Tyrolese Marksmen, whose fire was exceedingly deadly, felt obliged during the seven years' war to add a company of trained light infantry to the effective strength of each battalion.

In France the Cavalry were supplied with rifles before the Infantry. Towards 1674 Louis XIV. created some squadrons of Cavalry armed with "Carabins ragees." The name was given in France to all arms which were grooved, and it also served for the name of the corps which were first armed with them, viz., "Carabins."

In 1680 eight rifle carbines were carried in each troop of English Life Guards.

In 1691 the subaltern officers of the Swedish Dragoons received the rifled carabin, and in 1700 those of the Prussian Cavalry received the same rifled arms.

Experiments were tried with rifled small arms in England in the year 1776.

We read in the Scots' Magazine, vol. 36, that "the Guards are every day practising the use of the Rifle Gun in Hyde Park. On Saturday, April 27th, 1776, their Majesties attended a Review of the Rifle-men yesterday, and were much pleased with the dexterity of the officer, who loaded and fired several times in a minute, and hit the mark each time. He lies upon his back when he discharges his piece."

Austria kept 2000 Sharpshooters, having double carbines, which were supplied with a crotch to rest them upon while shooting. Only one of the barrels was rifled.

Rifles in Austria, 1778.

In 1793 the first model carbine for French Infantry was made at Versailles; at the same time the model for Cavalry was also fixed. Rifles were soon abandoned in the French Army; they deemed them of more trouble than profit.

Rifles in French infantry, 1793.

In 1794 the English adopted the Rifle, which, I fancy, was first used by a Battalion of the 60th, or Royal American Regiment.

Rifles, English, 1794.

In 1796 there were in the Austrian Army 15 Battalions of Light Infantry, the greater part of whom were armed with Rifles.

Rifles numerous in Austria, 1796.

In 1800, Rifles were placed in the hands of the 95th Regiment, now the Rifle Brigade of four Battalions. These Rifles weighed about 10½lbs. each, with the sword. They were sighted for 100 and 200 yards, with seven grooves, having a quarter turn in the length of the barrel, which was about 2 feet 6 inches, the length of the Rifle 3 feet 10 inches, weight of sword 1lb., diameter of bore .623. The locks were excellent, and had a detent, to prevent the nose of the sear catching at half cock, and it had a bolt, to prevent its going off at half cock. The ball was spherical, and driven in with a mallet, which was afterwards dispensed with, and a greased patch substituted.

Rifles for the 95th regt., 1800.

During the Peninsular War, our Riflemen were supplied with balls of two sizes, the easiest fitting being designed for use where celerity of loading was required. Baker, who made these Rifles, says in his Work, 1825, "I have found 200 yards the "greatest range I could fire to any certainty. At 300 yards I have fired very well at "times, when the wind has been calm. At 400 yards, and at 500 yards, I have "frequently fired, and have sometimes struck the object, though I have found it to "vary much."

Rifle ball in two sizes.

Range of English rifle.

Colonel Dickson, R.A., says, "In the early part of the present century, there was "also introduced a rifle-arm for cavalry. The barrel 20 inches, calibre 20 bore, "grooves 7, having the same pitch as those for the infantry; the 7th and 10th light "cavalry were the only regiments armed with them, but they were soon discontinued "from being considered as unfit for cavalry service."

Rifles in 7th and 10th Dragoons.

The Brunswick rifle was introduced in 1836. Weight with bayonet 11lbs. 5oz., length of barrel 2ft. 6-in., bore .704. Two deep spiral grooves with one turn in the length of the barrel. Sighted for 100, 200, and 300 yards. Bullet spherical and belted, diameter .696. Weight of bullet 557 grains. The shooting of this arm was superior to our first rifle, although the loading was not so easy as was desired, and a great disadvantage existed in the bullet and cartridge being separate in the soldier's pouch, the grooves were deeper and rounder than those of the ordinary rifle, the projecting zone of the ball was made to fit the grooves, the ball was wrapped in a linen patch dipped in grease. It was found that, although the rifle loaded easily at first, after constant firing the barrel became very foul, rendering loading nearly as difficult as under the old system of the indented ball. The belt on the ball caused considerable friction while passing through the air. (Plate 20, fig. 1).

Brunswick rifle.

Merits of the Brunswick rifle.

By a committee of officers assembled at Enfield, it was determined that all firing

with the Brunswick beyond 400 yards was too wild to give a correct angle of elevation. It was tested at Antwerp in 1844, in an experiment extending to 44,000 rounds, and declared to be the worst tried.

From France chiefly have proceeded most of the modern improvements in fire-arms.

The original French rifle (like our own) was loaded by force with a strong ramrod and mallet, and they found that it gave precision with diminution of range. For these reasons during the early campaigns of the French Revolution, the rifle was given up in the French army; but as their Chasseurs were found to be unequally matched against those of other armies, who surpassed them in accuracy as marksmen, a series of experiments were carried on at different times, with a view to its re-introduction into their service. No satisfactory result was obtained until the occupation of Algeria, when Mons. Delvigne, of the Garde Royale, took the first step in its restoration. In the flying wars kept up against them by Abd-el-Kader, they found that masses of their men were struck by Arab balls at distances where the French muskets were apparently powerless, and this they afterwards found arose from the long matchlocks of their enemies being fired at a much greater elevation than was ever thought of by European troops. In order to put themselves on an equality with their enemies, Mons. Delvigne showed in 1828 how the rifle bullet could be made to enter the piece easily, and quit it in a forced state; a method of loading as easy and simple as that of a smooth-bore arm. Expansion was obtained by the introduction of a chamber in the bore, which furnished an annular surface to receive the bullet, and on its being struck a small blow with the rammer it was expanded into the grooves. (Plate 20, fig. 2). The objection to the chambered rifle, was that after frequently firing, a residuum collected which eventually left the powder less room in the chamber, and of necessity it then reached above the shoulder of the latter, so that the ball resting upon the powder instead of upon the shoulder of the chamber, was not so readily dilated by the strokes of the ramrod into the grooves. To remedy this defect the wooden sabot and greased patch (plate 20, fig. 3) were suggested by Colonel Poncharra, in 1833, introduced into the French army 1839, and employed in Algeria, 1840, but several inconveniences attended its use.

Colonel Thouvenin endeavoured to overcome these difficulties by fixing at the bottom of the bore an iron shank, around which was placed the powder. This stem, (plate 20, fig. 4) stopping the bullet, allowed it to be struck in such a manner as to cause the lead to penetrate into the grooves. There is much fouling at the breech, and around the pillar of these rifles. They are difficult to clean, the soldier having to carry an instrument for this purpose. The Chasseurs and Zouaves of the African Army were armed with the tige in 1846.

At first a spherical ball had been used, and then a solid cylindro-conical bullet was resorted to; (Plate 20, fig. 6.) Messrs. Delvigne and Minie having long previously experimented with hollow cylindro-conical projectiles.

Some years after these experiments, Captain Minie proposed the adoption of a bullet which should receive its expansion by placing an iron cup in the hollow of the

Improve-
ments from
France.

French at dis-
count without
rifles.

Captain Del-
vigne's first
step to restore
rifles in
France.

The French
desired to be
on an equality
with Arabs.

Expansion by
chamber.

Defects of
chambered
rifle.

Poncharra
Delvigne rifle
1833.

Carabine a
Tige, 1842.

Defects of
Tige.

Tige intro-
duced, 1846.

Minie iron
cup.

base, which should be driven up by the gas, and force the walls of the cavity outwards, thus making them enter the grooves. (Plate 20, fig. 7.) In 1850 the Fusil range with ball culot was put into the hands of some French regiments of the line, and since then the French Imperial Guard have been armed with the old musket rifled, and a hollow bullet without a cup.

French army
1850.

At present it is understood that the French are rifling all their smooth bore arms, and the Russians are doing the same.

The Prussians have many thousands of their infantry armed with a breech-loading long range Rifle. The Russian Army is to have fifty-four rifle regiments, with a rifle company to each other regiment of Infantry. The Austrians are busy at work, according to their means. The Tyrol has always supplied them with a large number of marksmen. The Belgians are, I believe, universally armed with rifles, and even the little Kingdom of Portugal has ordered 28,000 rifles from Belgium.

Prussian.
army.
Russian
riflemen.
Austrian
riflemen.
Belgium.
Portugal.

Subsequent to the French experiments with the conoidal bullet, and the great results obtained over the spherical from it, it was proposed to adapt a conoidal bullet to the Brunswick Rifle. (Plate 20, fig 5.) This was done as an experiment, and succeeded very well, but at the same time the new arm, called the Miniè pattern, 1851, was also tried, and the shooting exhibited greater accuracy with this latter arm. Nothing further was done with the Brunswick rifle and conoidal bullet; and the (then called) "new regulation Miniè," was introduced into the service by the late Marquis of Anglesea, Master-General of Ordnance, with the approval of the late Duke of Wellington. Its weight with bayonet, was 10lbs. $8\frac{3}{4}$ ozs., bore .702, four spiral grooves, with one turn in 6 feet 6-in., powder, $2\frac{1}{2}$ drs., bullet, 680 grs., with iron cup, diameter of bullet, .690, windage, .012. When the axis is parallel to the ground at 4 feet 6-in. above it, the first graze is about 177 yards, and the angle of elevation at 800 yards, is $3^{\circ} 25'$.

Conoidal
bullet, with
Brunswick.

Miniè rifle,
introduced,
1851.

Performance
and angle of
Miniè.

A few years previous to the Russian war, rifles had attained to a degree of improvement in structure and adaptability to the general purpose of war, which threatened subversion to the established notions of the military world.

Consequences
of improve-
ments in mi-
litary rifles.

The artillery arm was menaced in its long rested monopoly of range and precision, with an equilibrium in hands it had never dreamed to find it; one which not alone would curb the wonted dash of field batteries to within the "shortest range," but also impress a more than wonted respect upon the best led and most daring cavalry, for even the thinnest formation of that arm, which it had hitherto been taught to despise. The Miniè was first used in the Kaffir war, and next at Alma and Inkerman, when it proved that the gallant Marquis had advanced a step in the right direction; who had ordered 28,000, but quarrels taking place among the contractors this order was never completed. The accuracy of firing from the Miniè was improved by altering the form of the bullet from conoidal to cylindro-conoidal, (plate 20, fig. 8.) and the iron cup from hemispherical to a conical shape with a hole in the apex.

Probable
effect on
artillery.

On cavalry.

Miniè in
Kaffir war.

Bullet im-
proved.

Lord Hardinge, succeeding to the post of Master-General, and after to that of Commander-in-Chief, zealously followed out the prosecution of the now becoming fixed idea, the general adoption for British infantry, of a pattern rifle-musket, which

Lord Har-
dinge's desire
for improve-
ment.

Experiments at Enfield. should combine lightness with solidity, precision, and superior range. Lord Hardinge opened competition to the leading British gun makers, when the following sent in muskets for trial, viz :—Purdy, Westley Richards, Lancaster, Wilkinson, and Greener. The Miniè pattern, (51), and Brunswick, (36), were also subjected to a course of trial before the committee assembled at Enfield, in 1852, for the purpose of determining the best description of fire-arm for military service.

Merits of the Brunswick.

The Brunswick rifle showed itself to be very much inferior in point of range to every arm hitherto tried. The loading was so difficult, that it is wonderful how the rifle regiments can have continued to use it so long, the force required to ram down the ball was so great as to render a man's hand much too unsteady for accurate shooting. Colonel Gordon, says, "It should be noticed here with the exception of Mr. Wilkinson, every one of the makers changed either his musket or projectile during the trials, thereby causing them to be protracted much beyond the time originally intended."

All had reduced bores. Elongated bullets.

Reversed cartridge. Best shooting from short rifle.

The diameter of the bore of all the new muskets was less than that hitherto in use, all the bullets were elongated and had auxiliaries for expansion, being metallic, or in one case a horn plug, one pattern had cannelures and the whole required the cartridge to be reversed in loading. It is worthy of remark that the best shooting at these trials was from a short rifle made at Enfield, which was named the artillery carbine, but not the one now used by the Royal Artillery. The barrel was only 2 feet 6-in. long, and the projectile cylindro-conoidal, with an iron cup weighing 620 grains ; thus proving that great length of barrel is not absolutely necessary in a rifle ; but a certain length of barrel is required to fire in double ranks, and so that the weapon may be effectually used as a pike. With a small bore, a greater number of rounds of ammunition may be carried, greater penetration, velocity, lower trajectory, and more accuracy, than with larger projectiles of equal weight. The alleged disadvantages of small bore are, the slender form of cartridge and the smaller hole made in a man's body, as stated to be proved in the case of wild animals, in proof of which it is said that they are found to run further when wounded with a small ball, than they do with a large one ; but this reasoning does not seem applicable to the human race, for it is presumed that few men would be found willing to move far when wounded by a musket ball, whether the hole in their body was $\cdot 702$ or $\cdot 530$ of an inch in diameter.

Advantage of small bore.

Disadvantages of small bore.

Objection to reversing the cartridge.

An absurd objection was stated as to reversing the cartridge, viz :—that drill with blank would be performed in a different manner to firing ball, and that in action the soldier would forget to reverse his cartridge, and put in the ball first. As we now always perform our drill, and as our present blank cartridges require to be reversed or will not ignite, this objection is removed. It also was said that mice, rats, &c., &c., would eat off the lubricating mixture!!

The Enfield rifle.

It was proposed to give the Enfield, (1853,) a back sight to 900 yards, when an outcry was raised against the monstrous proposition of giving to every common soldier a delicately made back sight, whether he knew how to use it or not!!! and those rifles first issued, were only sighted to 300 yards.

At the conclusion of the trials at Enfield, in August, 1852, two rifles were made

at the Royal Manufactory, in which were embodied the improvements and alterations suggested by the experience obtained during the course of the trials, and which was hoped would possess the necessary requirements for a military weapon, and which proved superior to the Miniè, the Brunswick, and all those presented for trial by the different manufacturers.

This beautiful rifle though $2\frac{1}{2}$ lbs. less than the old musket, is fully as strong, and as capable of rough usage. Weight, including bayonet, 9 lbs. 3 ozs., bore, .577, length of barrel, 3 feet 3-in., weight of barrel, 4 lbs. $\frac{1}{2}$ ozs., three grooves with spiral of one turn in 6 feet 6-in.; the barrel to be fastened to the stock by bands. The bayonet to be fixed by means of a locking ring. The lock to have a swivel. The bullet was of a pattern suggested by Mr. Pritchett. (Plate 20, fig. 9.)

Dimensions,
&c., of Enfield

Lord Hardinge, desirous to improve the projectile, and if possible to get rid of the cup, having requested the leading gun makers to lay any suggestions before the small arms committee, none were submitted but one by Mr. Wilkinson, which was not a compound. It was solid with two deep cannelures, but it lost its accuracy when made up into a cartridge, and made very wild practice beyond 300 yards. (Plate 20, fig. 10.) Subsequently a bullet was proposed by Mr. Pritchett, being cylindro-conoidal in form, with a small hollow at the base, which was made more to throw the centre of gravity forward than to obtain expansion thereby. This bullet weighed 520 grains, or 24 guage, and excellent practice was made with it at Enfield, from 100, to 800 yards, and it was accordingly introduced into the service, to the suppression of the Miniè, with iron cup; and for which Mr. Pritchett, received £1,000.

Attempts to
improve the
bullet.

Description of
Pritchett.

Shortly after the establishment of the School of Musketry, in June, 1853, twenty Enfield rifles were sent down for trial in competition with the Miniè, and also with "Lancaster's smooth bore elliptical rifle, with increasing spiral and freed at the breech," when the Enfield was found to be superior to both. It is stated that Mr. Lancaster's invention is intended to overcome the inconvenience attendant on the wearing out the rifle ridges, by the ramrod, &c.; these rifles are also easily cleaned, the difference in width between the major and minor axis of the ellipse was, $\frac{7}{100}$ of an inch.

Lancaster
smooth bore
rifles.

Carbines on this principle are now carried by the Royal Engineers, and shoot well, and by some persons are thought to be superior to the Enfield, 1853; they fire the same ammunition, and there is no question but that their firing is much more accurate from using the improved wooden plug bullet.

Engineer
Carbine.

In May, 1855, the ammunition was found to be in a most unsatisfactory state and unfit to be used, there being bullets of various diameters in many of the packages of the cartridges. The correct size of the Pritchett bullet viz., .568, was found to produce accurate shooting, at 600 yards, while bullets of a smaller diameter fired very badly.

Failure of the
Pritchett.

To get out of this difficulty, Colonel Hay recommended the application of the iron cup to the bullet, which was approved, when more uniform expansion resulted and greater accuracy.

Return to
iron cup.

Thus by using an auxiliary to expansion there is a margin left to cover any trifling inaccuracy in manufacture, in diameter of either bullet or bore.

Woolwich
account for
bad *ammunition*.

The Woolwich authorities stated that they had seven dies at work making bullets, and which were made small at first as they gradually wore larger; when any one die became too large it was destroyed, and replaced by a smaller one. To this cause they imputed the failure of our Pritchett ammunition. It was afterwards suggested from the School of Musketry, to procure expansion by using a wooden plug, and after most extensive experiments, this was found to be superior to any description of bullet yet tried at Hythe, and the wooden plug has accordingly been established for the British army. (Plate 20, fig. 11.)

On expansion

Uniform accuracy mainly results from the bullet continuing to receive a sufficient and uniform expansion into the grooves, so that the projectiles get such an amount of rotation as shall last until they have reached the object fired at. The more perfect the expansion, the less the accumulation of fouling and consequently accuracy is further increased.

The Enfield has frequently been fired to 200 rounds and the loading continued easy.

Progressive
grooving 1858

Early in 1858, the regulation rifle, (53), was changed from grooves of uniform, $\cdot 014$ in depth, to $\cdot 005$ at muzzle, increasing in depth to $\cdot 015$ at the breech; while new, these rifles shoot well, but they require increased elevation at long ranges. How far these shallow grooves will answer, or how long it will take to convert these arms into smooth bores at the muzzle, by the continued friction of the ramrod, remains to be seen.

Origin of
progressive
grooving.

Captain Panot, of the French service, states, "it is but a few years since all our "smooth bore barrels were reamed so that they would carry the spherical ball of $\cdot 669$, "instead of $\cdot 641$. It was afterwards determined to convert these arms into rifles. To "prevent weakening the reamed up barrels, M. Tamisier proposed to vary the depth "of the grooves, making them deeper at the breech than at the muzzle." Grooves thus made, are said to have a greater accuracy of fire from keeping the ball perfectly tight as it leaves the bore and destroying all windage at the muzzle. This is called "progressive grooving." Rifles upon this principle require to be fired at an increased elevation, attributed to the greater amount of friction experienced by the bullet while passing down the barrel.

Advantages.

Short Enfield

Rifle regiments and all serjeants of infantry have been furnished with a weapon requiring the same ammunition as the regulation arm, but six inches shorter, being mounted in steel, with a sword bayonet.

Royal Navy
rifle.

A five "grooved progressive" carbine has recently been given to the Royal Marine Artillery and the Royal Navy, with the same bore as the Enfield.

RIFLED BREECH-LOADERS.

Early guns
loaded at the
breech.

It is worthy of notice that, while numerous attempts are now making to perfect the breech-loader for sporting as well as military purposes, our early cannon and first hand guns were loaded at the breech, and if all mechanical difficulties could be overcome, the breech-loading principle for portable fire-arms would deserve the preference.

We can easily understand why it did not continue in favour in early days, as this mode includes a great deal of perfection in mechanical workmanship, and to which the ancient gun maker was a stranger.

The great argument against breech-loaders as military weapons is the expense, their intricate construction, the escape of gas, and the probable waste of ammunition, in the hands of an uneducated soldier. It may be briefly answered.

1st.—As to expense, the most destructive weapon, by preventing and curtailing war, must in the long run be the cheapest.

2nd.—As to intricacy of construction, the soldier is the user, not the maker of his gun; it matters not how delicate the mechanism of a watch may be, the only question is, does it continue to go well!! And who dare say that the brains of man shall never suggest a simple mode of construction. Of course anything fragile would be totally unfit for military purposes. The escape of gas has been entirely overcome.

3rd.—As to waste of ammunition, is it absolutely necessary that a soldier should remain uneducated? Are not soldiers men? And men can be taught almost anything, or are they incapable of being taught? Does a soldier fire how, when and where he chooses? Is it too high an aspiration that the British army should carry the best arm that can be made, to be placed in the hands of a taught and skilful soldier, acting under the guidance and control of intelligent officers?

As far as the arm only is concerned, breech-loaders have now (1860) attained a high degree of perfection, as is proved by the deserved celebrity of that made by Mr. Westley Richards. The only remaining difficulty is one of ammunition. Loose powder cannot be employed in loading with a breech as it can with a muzzle-loader. We are up to this time under the necessity of introducing the whole of the cartridge, this of course augments fouling and lessens accuracy; there is also increased difficulty in producing ignition through the fold of the cartridge paper.

Recently a most ingenious mode of compressing the grains of powder contained in a charge into one mass, so that every description of rifle may be rapidly loaded without any paper, has been invented by Captain Brown, R. N., and I have every hope and confidence that the only remaining breech-loading difficulty may now be considered overcome.

The advantages of breech-loaders, are, 1st.—Celerity of fire, about ten wounds a minute have been attained. 2nd.—The soldier can load while lying flat on the ground. 3rd.—The barrel can be easily cleaned and examined as to its state. 4th.—A solid ball can be fired, and with less windage.

Various modes of self capping have been brought forward, but that by Maynard seems to merit the preference; time is further economized, and the powers of the breech-loader thereby increased.

Our cavalry regiments in India, are partially armed with breech-loading rifles, and all their pistols are rifled, and upon the tige principle.

The whole of our Guards, regular Infantry, Royal Marines, Militia, and Royal Engineers, are armed with rifles, and the Carabine used by the Royal Artillery, is also

Disadvantages of breech-loaders.

1st. As to expense.

2nd. As to intricacy.

3rd. As to waste of ammunition.

Breech-loaders highly improved.
Ammunition the difficulty.

Capt. Brown's compressed powder.

Advantages of breech-loaders.
1st. Celerity
2nd. Load lying down.
3rd. Easily cleaned.
4th. Solid ball Self capping

Cavalry have breech-loaders.
Rifles universal in English army.

rifled. All our Colonial corps are supplied with rifled arms, with the exception of the Native corps, serving in the East Indies and Ceylon.

In larger
numbers.

Taught to use

Prizes.

Thus rifles are introduced in larger numbers and of better quality in the armies of England, in proportion to their numbers, than amongst any other nation. While more care and expense is incurred in qualifying our soldiers efficiently to use them. In illustration of which, it is only needful to call attention to the simple fact that £20,000 per annum is distributed as a stimulus to the marksmen of the British army, for which boon all honour to our Royal Commander-in-Chief.

Explosive
shells.

The idea has recently been revived to increase the destructive powers of Infantry, by furnishing them with shells, with which they may explode ammunition waggons, artillery limbers, &c., &c., to the distance of 1,000 yards. Captain Norton, Mr. Dyer, Colonel Jacobs, and Mr. Whitworth, have directed their minds to this most important subject.

ON RIFLING.

It has been stated that amongst the different gun makers who assembled at Woolwich, for the carrying on of experiments in 1851, no two agreed upon any one thing; and in 1860, it may still be averred, with almost equal truth, and that it yet remains an unsettled question as to the form, width, depth, number or degree of spirality of the grooves, as also the harmony which should subsist between the grooves, diameter of bore, the form and weight of projectile, and the quality and quantity of charge.

Robins, in 1742, says, "rifles though well known on the continent, being but "little used in England, it is necessary to give a short description of their make. "The rifle has its cylinder cut with a number of spiral channels, so that it is in reality "a female screw, varying from the fabric of common screws, only in this, that its "threads or rifles are less deflected and approach more to a straight line." The advantage of a rifle (with a round bullet), is that the axis of rotation not being in any accidental position, as in a smooth bore, but coincident with the line of its flight, it follows that the resistance on the fore part of the bullet is equally distributed round the centre of gravity, and acts with an equal force on every side of the line of direction, and also should the resistance be greater on one side of the bullet than the other from irregularities on its surface, as this part continually shifts its position round the line in which it is proceeding, the deflections which this irregularity would occasion are neutralized. With an elongated projectile rifling also prevents it from rotating round its shorter axis.

It is to the artisans of Germany, that the rifle owes its origin, as at the close of the fifteenth century barrels with straight grooves were used by the citizens of Leipsic, at target practice, in 1498, and the invention of grooving or rifling fire-arms is generally supposed to be the result more of accident than theory. In Dean's Manual of fire-arms, it is stated that, "the idea of grooving arms in the direction of the axis of the "barrel to receive the residuum of the powder, and thereby, not only facilitate the "loading, but increase both the bite or forcing of the ball, by impressing upon it the "grooves, and thus maintain it during its passage through the barrel in a direction "more in harmony with the line of fire, was doubtless a conception based upon no "previous theory or practice now to be traced, but was formed in that suggestiveness "which in the individual founds for itself a theory based upon the likelihood of "possible result. Upon trial also of the straight grooves a greater precision for

Description
of Rifles.

Advantages
of a rifle.

Rifling inven-
ted in Ger-
many.
Rifles used
1498.

Straight
grooves.

"short distances would have been observed than with the smooth bore." This must of itself therefore have led to the establishment of a certain grade of theory which it was endeavoured to amplify by various means, such as increasing the number of grooves, then of changing the inclination of grooves from the straight line to the spiral.

To deem that the practised crack "shots and armourers of a time when target practice was the constant recreation of the citizen, and his pride to excel in, were so brainless as to conceive no theory, unelaborated though it may have been, and that all their even now admired efforts in Germany, were the products of mere accident, is therefore scarcely a rational supposition."

It is stated that Koster, of Nuremburg, in 1522, first suggested giving a spiral form to the grooves, and experience proved that much greater accuracy of shooting was the result.

In 1552, Damer, of Nuremburg, made some great improvements in rifles, but we are not aware of their precise nature.

Koster, of Nuremburg, who died 1630, by some authorities is said to have discovered that straight grooves did not fulfil the intentions of their inventor, and to have been the first who suggested spiral grooves in 1620.

The important stage next arrived at was the scientific explanation of the true value of spiral grooves. The honor of this entirely belongs to our countryman, Benjamin Robins, who in his Principles of Gunnery, gives a complete and satisfactory explanation of the action of the grooves in determining the flight of the bullet. Robins, states that "the degree of spirality, the number of threads, the depth the channel are cut down to, are not regulated according to any invariable rule, but differ according to the country where the work is performed, and the caprice of the artificer. The most usual mode of charging rifles is by forcing the ball with a strong rammer and mallet. But in some parts of Germany and Switzerland, an improvement is made by cutting a piece of very thin leather or fustian in a circular shape, somewhat larger than the bore, which being greased on one side is laid upon the muzzle with its greasy part downwards, and the bullet being placed upon it, is then forced down the barrel with it. When this is practised the rifles are generally shallow, and the bullet ought not to be too large.

As both these methods of charging rifles take up a good deal of time; the rifled barrels which have been made in England, (for I remember not to have seen it in any foreign piece,) are contrived to be charged at the breech, where the piece is made larger, and the powder and bullet are put in through an opening in the side of the barrel, which, when the piece is loaded is fitted up with a screw. And perhaps somewhat of this kind, though not in the manner now practised, would be of all others the most perfect method for the construction of these sorts of barrels."

ON THE NUMBER, FORM &c., &c., &c., OF THE GROOVES.

Almost every description of twist, number, &c., &c., of grooves have been tried, according to the individual tastes and theories of the manufacturers. It is absolutely

Spiral
grooves, by
Koster, of
Nuremberg in
1522.
Damer of
Nuremberg,
1552.
Koster of
Nuremberg,
1620.

Robins first
explained
action of
grooves.

Robins struc-
ture of rifles.

Modes of
loading.

Early rifles,
breech-
loaders.

Number of
grooves.
Degree of
spirality.

necessary to have two grooves, as a single one would give a wrong direction. Rifles have been made with, from two to one hundred and thirty three grooves, and in the majority of cases, an odd seems to have been preferred to an even number. In Dean's Manual it is stated, that "in the numerous collections of arms that have at various times come under our personal notice, some were rifled with straight, but the majority with grooves in a spiral line, sometimes with a half, sometimes a three quarter, and seldom more than a whole turn in a length of two, two and a half and three feet; deviations based upon no principle transmitted to us, but requiring nevertheless a decided research for principles upon which to establish a theory; we have also met with every one of those configurations of the spiral and form of groove, &c., &c., which have been arrogated as modern conceits and discoveries."

Some rifles have sharp muzzle twist decreasing to the breech;—sharp breech twist decreasing to the muzzle; an increase of twist in the middle of the barrel decreasing at both extremities.

In France a modification of the Carabine took place in 1740; —the grooves were made to begin at eight inches from the muzzle, the unrifled part being of the same calibre as the bottom of the grooves, so that the bullet might pass easily; thus also facilitating the loading of the weapon.

There is an old rifle in the United Service Institution, and also a barrel brought from Lucknow, (in the Model Room of the School of Musketry,) grooved only for about one foot from the muzzle, the remainder of the barrels are smooth bored.

The degree of spirality is found to vary from a whole turn in 1 foot 5-in., to a whole turn in 11 feet.

The depth of grooves vary from .005 of an inch, to about .125; and some rifles have been made with an alternate deep and shallow groove.

Grooves have been made round, circular, triangular, rectangular, and indefinite, alternate round and angular, elliptical, polygonal; and some cut deep only on one side.

Some gun makers are of opinion that there should be a greater proportion of groove or furrow than of land or plain surface, because they say the ball is thus more firmly held, while others maintain that by diminishing the number of the grooves, the accuracy and range would be increased, and this has led to the opposite theory, that perhaps if anything, the plain surface of the bore should predominate over the grooved.

The earliest rifles had two straight deep creases opposite to each other, the bullet being spherical, and furnished with small circular knots of lead, large enough to fill the creases.

The greater number of ancient rifles have a whole turn, with an odd number of deep and rounded grooves; hence we may infer these were considered the best forms.

As accuracy of direction is the result of a spiral motion round an axis coincident with the flight of the bullet, communicated to it by the grooves, it is clear that the depth, number, and form of the grooves should be such as will hold the bullet firmly, and prevent all tendency to strip.

The degree of spirality should be sufficient to retain the projectile point foremost during the whole of its flight. It was at one time supposed that if the spiral turn was

Spirality.

Modification
in France.
1740.

Rifled only at
muzzle.

Degree of
spirality.

Depth of
spiral.

Form of
grooves.

Proportion of
groove to land

Form of early
grooves
straight.

Form &c., of
ancient rifles.

Objects of
rifling.

On the degree
of spirality.

great, and the charge strong, the bullet would not conform, but strip, and that the same results would occur even with grooves but little curved. Unquestionably this would prove true if certain limits were to be exceeded. A false conclusion was built upon this theory, viz., that the greater the spiral turn the less the charge should be; and that therefore in rifles intended for war, the greatest initial velocity being required to produce the greatest range, the groove should have as little turn as possible. For, extreme ranges have been obtained with Jacob's, Whitworth's, and Lancaster's rifles; the first has a full turn in 24in. the second in 20in. These rifles perform well with 90 grains of powder, and both Whitworth's and Lancaster's might even fire better were the charge of powder increased to 100 grains, the recoil might be objectionable while there would be no symptoms of stripping.

Sharp twist
and large
charge not
cause strip-
ping.

On depth of
groove.

Great depth of groove can only be hurtful, owing to the difficulty of closing up all passage to the gas, which should not be allowed to escape round the bullet, as this would cause deviation and shorten range. Deep grooves become a receptacle for fouling, are difficult to clean; and high projections must offer great resistance to the atmosphere, and particularly to a side wind.

Patches.

When fustian or leather are used as patches, they receive and communicate the spiral motion to the bullet, without the zone of the projectile being at all indented, but in this case the spiral must be diminished, otherwise the bullet would not turn with the grooves. If the patches be made of a thick material, the grooves should be many, broad, and not too shallow, in order to receive the folds of the patch.

Shallow
grooves best.

From our present amount of experience it seems safe to conclude that the shallower the grooves are the better, so that they perform their intended functions.

Proportion of
groove to land

It is now generally recommended that the grooves be made broader than the lands, *i.e.*, that the rifling surface should predominate over the unrifled part of the bore. Shallow grooves with rounded edges, have the advantage of not leaving any angular traces on the surface of the bullet, besides they afford a greater facility for cleaning.

Circular
grooving.

Circular grooving is composed of segments of circles, leaving no sharp edges on the bullet, and is no doubt a very good form.

Gaining twist.

An American gentleman named Chapman, who has written a very clever book upon the rifle, is a strong advocate for the "gaining twist," which form prevails generally in American rifles. He states, "In a rifled barrel, it is obvious that a bullet "instantaneously started from a state of rest, with a velocity of 5,000ft. a second, "must exert at the moment of starting, a tendency to move along the bore in a "straight line. However, meeting with the resistance that the lands employ to keep "it to the twist, it communicates to the rifle itself a certain amount of motion in the "direction of the twist of the creases, and this as the angle of the twist increases, "combined with the size of the calibre, and the weight of the ball."

Cause of
canting.

Remedy for
canting.

"If the angle of the twist at the breech end can be reduced, the bullet at the "same time leaving the muzzle with sufficient spin to last throughout its flight, it is "certain we shall have less twisting of the rifle in the marksman's hands, less friction "of the bullet against the lands, less tendency for the bullet to upset, (or be des-

“troyed,) and consequently, from obtaining a higher velocity, (because enabled to “use a greater quantity of powder,) less time for the action of regular or irregular “currents of air.”

After careful experiments by the American Government, preparatory to the establishing the model for their Military Rifle, it was decided that the turn for the grooves should be uniform; and that those with an increasing twist did not give any superiority of accuracy. The “gaining twist,” although adopted by Mr. Lancaster, is opposed by Mr. Whitworth, and all other Rifle manufacturers, and our increased experience does not prove it to possess any advantages over uniform spirality. Theory would indicate that it must occasion increased friction.

Uniform
spiral by
American
Government.

Mr. Greener advocates decreasing spirality. It is to be hoped he is the only advocate for so seemingly absurd an idea. To give a certain measure of spiral turn at the breech, to be withdrawn gradually as the bullet reaches the muzzle, is simply ridiculous, and which, with other conceits previously referred to, it is to be hoped are no more to be repeated.

Decreasing
spiral.

By the desire of our first Patron, the late Lord Hardinge, Mr. Whitworth was induced to turn his mechanical genius to the Soldier's Gun, which resulted in his adopting the polygonal form of bore. His barrel is hexagonal, and thus, instead of consisting of non-effective lands, and partly of grooves, consists entirely of effective rifling surfaces. The angular corners of the hexagon are always rounded. Supposing a bullet of a cylindrical shape to be fired, when it begins to expand it is driven into the recesses of the hexagon. It thus adapts itself to the curves of the spiral, and the inclined sides of the hexagon offering no direct resistance, expansion is easily effected.

Polygonal
rifling.

Mr. Westley Richards has followed Mr. Whitworth, by using a polygonal bore, having applied his highly meritorious system of breech-loading to a barrel upon the Whitworth principle, of an octagonal form.

Westley
Richards
octagonal.

The cardinal feature of this structure is, that the bore of the barrel is smooth, and instead of being circular, is cut into the form of an ellipse, *i.e.*, it has a major and minor axis. Upon being expanded by the force of the powder, the bullet is forced into the greater axis of the ellipse, which performs the office of the grooves, rifling the projectile, and imparting to it the spiral or normal movement round its own axis. In 1835 a Captain Berner submitted his elliptical bore musket to the inspection and trial of the Royal Hanoverian Commission, appointed for that purpose, and which gave results so satisfactory, that it was considered admirably adapted for the Jäger and Light Infantry Battalions. This principle has been patented by Mr. Lancaster, and the advantages of this form have been previously adverted to.

Elliptic rifling.

By Captain
Berner, 1835.

It is supposed by some persons that if the number of grooves be even, so that they will be opposite to one another, the bullet would then require more force to enlarge it, so as to fill them properly. If the number be unequal, the lands will be opposite to the grooves, and the lead, in forcing, spreading on all sides, will encounter a land opposite to each groove, which will in some measure repel it, and render its introduction into the opposite groove more complete.

By Mr.
Lancaster.

Odd number
of grooves.

This ingenious theory is set at nought by Whitworth, Jacobs, Lancaster, W. Richards, &c., &c., who all recommended an even number of grooves, while the Government arms have an odd number.

Drift or cant.

If the grooves twist or turn over from left to right, the balls will be carried to the right; and if from right to left, they will group to the left; and this result will be great in proportion to the degree of spirality. The causes of Drift or "Derivation" will be treated of hereafter. We know from observation that the majority of balls strike to the right of the mark. The recoil and *pulling* the trigger throw back the right shoulder, which tend to increase the "derivation" to the right. If the twist were, then, from *right* to *left*, the drift, error from *pulling*, and from recoil, would tend to neutralize each other; the twist of the grooves should therefore be from right to left, instead of the present universal practice of from *left* to right.

On length of barrel.

The barrel of a gun may be looked upon as a machine in which force is generated for the propulsion of the bullet. It is well known that the continued action of a lesser force, will produce a much greater effect, than a greater amount of power applied suddenly; hence mild gunpowder is more suitable for rifle shooting than strong, or that which evolves the whole of its gas instantaneously. Time is necessary for the entire combustion of a charge of gunpowder, consequently more mild gunpowder can be fired out of a long, than out of a short barrel, as if fired out of a short barrel, some of the grains might be ejected unconsumed. All extra length, after the last volume of gas is evolved, can only be injurious, by causing loss of velocity from friction. A billiard ball would travel none the further nor straighter, were it to be propelled through a hollow tube, neither would a barrel to a cross bow aid in killing rooks. A barrel favours expansion of the bullet, which is produced by the force of the generated gas, opposed by the column of air in the hollow tube and by the motion of the projectile. Facility in aiming is promoted by the sights being distant from each other. In a military arm a certain length is necessary in order to fire when two deep in the ranks, and length is also advantageous, should the rifle be used as a pike.

Favors expansion.

Assists aiming, firing two deep: when using bayonet.

Advantages of short rifle.

Disadvantages of short rifles.

The short rifle can be held steadier when standing, by a weak man, and during wind, it is handy when passing through a wood or thicket, and a very short man has more command of his gun when loading; but with the sword bayonet, it is heavier than the long Enfield and bayonet; while the sword is very inconvenient when running, firing kneeling, or lying down.

Thickness of barrel.

Great substance was at one time considered necessary for accurate firing, it being supposed necessary to prevent vibrations in the barrel; this is true within certain limits, and the heavier the charge, the heavier the metal ought to be, especially at the breech, but diminishing the thickness, has been proved in no wise to lessen the accuracy. A heavy barrel also lessens recoil, but it would be folly to carry more weight than would neutralize the recoil which could be produced by a greater charge of powder than could be consumed in a given length of barrel.

Size of bore.

The two grand requirements of a soldier's gun are, celerity of loading, combined with accuracy at long ranges; and the distance at which he should have the power of firing, should be limited by the strength of his eye. The weight of the projectile

being fixed (.530 grs.), good shooting at extreme distances can only be obtained by reducing the diameter of the bore, which, lessening the frontage of the bullet, causes it to experience less resistance from the air; it therefore retains a higher degree of velocity than a larger bullet of the same form and weight, and therefore travels further and faster. Gravity has less time to act upon it, in a given distance, and therefore it can be fired at a lower angle, or has what we call a lower trajectory, and its accuracy is increased in direct proportion to the lowness of its flight, all other things being equal.

While the best form, &c., &c., for rifles is not yet determined, there are many points upon which the generality of persons seem more agreed, viz., reduction of bore to about $\frac{1}{2}$ -in. in diameter, fewer grooves, shorter barrel, and with increased spirality; at least, one may safely say that ideas seem to travel in this direction.

Best form of rifling still undetermined

ON RIFLE PROJECTILES.

We have learned that out of early Artillery were fired bolts, darts, bombs, stones and (more recently) iron shot. From the harquebus and musket: arrows, darts, quarrels, sprites, iron, and lastly leaden spherical balls. Some assert that the idea of lengthened elliptical bullets was enunciated so far back as 1729, and that good results followed their employment, but it is doubtful whether such really did take place.

Projectiles used in early guns.
Elliptical iron bullets 1729.

Leutman, in his "History of St. Petersburg," says that "it is very profitable to fire elliptical balls out of rifled arms, particularly when they are made to enter by force."

Leutman.

Robins, in 1742, recommended the use of projectiles of an egg like form, (see plate 20, fig. 12), they were to be fired with the heavy end in front, to keep the centre of gravity forward.

Robins 1742.

Colonel Beaufoy, in a work called "Scloppetaria," 1812, remarks that several experiments have been tried with egg-shaped bullets, recommended by Robins. It was found, however, that these bullets were subject to such occasional random ranges, as completely baffled the judgment of the shooters to counteract their irregularity. Their deviations to windward most likely arose from the effect of the wind on the after part, which, as being the lightest of the two, was driven more to leeward, and consequently acted as a rudder to throw the foremost end up to the wind.

Beaufoy 1812

In 1770 Messrs. Turpin tried elongated bullets, at La Fiere, and at Metz.

Turpin 1770.

We are informed, in the Annual Register for 1776, and also in the Scots Magazine for the same year, that rifled Ordnance were experimented with at Languard Fort, &c., &c., in 1774. Dr. Lind, one of the inventors, states that to remedy the deflection of shot, "One way is to use bullets that are not round but oblong. But in our common guns that are not rifled, I know no way to prevent deflection, except you choose to shoot with a rifled bullet."

Rifled guns &c., 1776.

Elongated Projectiles were tried in the years 2, 6, and 9 of the Revolution, by Mons. Guitton de Moreau. They were proposed by Mons. Bodeau. In 1800 and

Elongated projectiles 1789.
1800 and 1815

1815 the Prussians tried ellipsoidal bullets. Colonel Miller, Colonel Carron, Captain Blois, and others, also experimented with the cylindro-conical form.

Captain
Norton 1824.

Captain Norton (late 34th Regt.), the original inventor of the application of the percussion principle to shells for small arms, in 1824, completed an elongated rifle shot and shell, the former precisely of the form of the Miniè bullet, with projections to fit the grooves of the barrel.

Mr. Greener
1836.

Mr. Greener, in 1836, presented an expanding bullet to the Government for experiment, (plate 20, fig. 13). It is oval, with a flat end, and with a perforation extending nearly through. A taper plug, with a head like a round-topped button, is also cast of a composition of lead and zinc. The end of the plug being slightly inserted in the perforation, the ball is inserted either end foremost. When the explosion takes place, the plug is driven home into the lead, expanding the outer surface, and thus either filling up the grooves of the rifle, or destroying the windage of the musket. The result was favourable beyond calculation. Of about 120 shots by way of experiment, a man was able to load three times to one of the old musket, and accuracy of range at 350 yards was as three to one.

Mr Greener's
invention
rejected.

Mr. Greener's invention was rejected, and the only notice he received from the Board was, it being "a compound," rendered it objectionable!!!

Mr. Greener
rewarded.

The following extract appears in the Estimates of Army Service for 1857-8. "To William Greener, for the first Public Suggestion of the principle of expansion, "commonly called the Miniè principle for bullets in 1836, £1,000."

Wilkinson
1837.

Many experiments were made by Mr. Wilkinson in 1837, with balls precisely similar in shape to the Miniè, with a conical hole in them, using a wooden plug; and in 1851 experiments were tried at Woolwich with a soft elastic cork, fitting the aperture in the projectile very closely, the compression of which it was conceived would sufficiently expand the cylindrical part, and make it fit the grooves, &c. In some instances it succeeded perfectly, but in many the cork was driven through the lead.

Cork plug
1851.

Gen. Jacobs.

Major-General Jacobs for many years carried on a series of experiments with rifles, and in 1846 submitted a military rifle, with an elongated projectile, for experiments, to the Government at home, and also to that in India. It did not meet with approval in England, and the Company cut the matter short by stating, that what was good enough for the Royal Army was good enough for theirs. There is nothing peculiar in General Jacob's rifle. He recommends an elongated projectile (plate 20, fig. 14) solid at the base, cast with four raised flanges to fit into the grooves. General Jacobs states, that the desired initial velocity could not be produced with a projectile made entirely of lead, as a slight increase of charge had the effect of destroying the form of the projectile. He also states that the limit of the powers of leaden balls having been attained, it became necessary to find a method of constructing rifle balls, so that the fore part should be capable of sustaining the pressure of large charges of fired gunpowder, without change of form, and retain that shape best adapted for overcoming the resistance of the air, on which all accurate distant practice depends; and at the same time having the part of the ball next the powder sufficiently soft and

Form of
leaden bullet
destroyed.

yielding to spread out under its pressure, so as to fill the barrel and grooves perfectly air tight. And he professes to have solved the problem, by having the fore part of the bullet cast of zinc, in a separate mould.

Zinc point to bullets.

Captain Delvigne, who had been experimenting since 1828, proposed the adoption of lengthened bullets, consisting of a cylinder terminated by a cone, which was subsequently replaced by an ogive. He obtained a patent dated 21st June, 1841, "For having hollowed out the base of my cylindro-conical bullet, to obtain its "expansion by the effect of the gases produced through the ignition of the powder."

Expansion by hollow bore.

The main object of Captain Delvigne in hollowing the base was, to throw the centre of gravity forward; but a Captain Blois, in France, had previously tried this important suggestion. Captain Delvigne states, if the hollow is too deep, the expansion is too great, and the consequent friction enormous; or the gas may pass through the bullet, and leave a hollow cylinder of lead within the barrel. Sometimes the gas will traverse the sides of the bullet, and consequently the projectile is deprived of a proportionary amount of velocity; if too small, the expansion does not take place.

Hollow in case to throw centre of gravity forward.

Captain Minié, an instructor of the School at Vincennes, merely fitted into this hollow an iron cup, hoping to prevent the gas forcing its way through the bullet, and that the iron pressing upon the lead should increase the expansion. (Plate 20, fig. 7).

Capt. Minié iron cup.

A perfect bullet was now supposed to have been discovered, of a cylindro-ogival form, (no part was a true cylinder), having a groove originally intended to fasten on a greased patch, and in some cases the cartridge, but the patch being dispensed with, and the cartridge reserved, the groove, supposed to be useless, was suppressed.

Groove suppressed.

People were then surprised to find that firing lost much of its accuracy, and the groove was replaced; when it was observed that any variation in its shape and in its position, materially affected the practice. Not only variations in the grooves caused great alteration in the accuracy of fire, but any modification bearing on the trunk in rear, or on the fore-ogive, altered the conditions of the firing, so that the groove became lost in the midst of so many other principles, the functions of which were so much unknown. These theoretical considerations served, however, as a point of departure for further investigations.

Results.

Captain Tamisier had not ceased for several years, concentrating his attention on the subject. He varied the length of the cylindrical part and the angle of the cone, and tried experiments with bullets of 5-in. in length, and obtained considerable range, and great accuracy with them; the recoil however was excessive, and to use such bullets heavier arms, a smaller bore, and other modifications would be necessary.

Tamisier lengthened bullets.

He endeavoured to carry the centre of gravity to the furthest possible point forward, (which Robins suggested 100 years before), but to effect this he was compelled to flatten the fore end of the bullet, which had the disadvantage of increasing the resistance of the air to the movement of projection.

Centre of gravity formed by blunting tips.

He was then led to another plan for rectifying the path of the bullet through each instant of projection, and which was by creating at the posterior end, resistances, which should act in case the axis of the bullet did not coincide with the direction of

Path rectified by resistance in rear.

Many
cannelures.

motion, and this was carried out by cutting upon the cylindrical part, instead of one, as many circular grooves of $\cdot 28$ in depth, as that cylindrical, or rather, slightly conical, part could contain. An increased precision in firing was the immediate result. (Plate 20, fig 15.)

Shape of
cannelures.

Feeling his way most carefully, Captain Tamisier then made a great number of experiments in this direction, and perceived that it was important to render the posterior surface of the grooves as sharp as possible, so as to augment the action of the air; for these grooves lose their shape, owing to the lead, from its malleable nature, yielding under the strokes of the ramrod.

Elongated
Projectiles,
whose Centres
of Gravity do
not corres-
pond with
Centre of
Figure.
Action of the
air.

Elongated projectiles, whose centres of gravity do not exactly coincide with the centre of figure, when they do not turn over, tend to preserve their axis in the primary direction which was imparted to them, in the same manner as an imperfectly feathered arrow flying with little velocity, the point of the moving body being constantly above the trajectory, and its axis making a certain angle (plate 21, fig 1) with the target to the curve. Therefore the part A.B. of the bullet being exposed to the direct action of the air's resistance, the atmospherical fluid is compressed on the surface A.B., and rarified upon that of A.C. Hence it will be perceived that the compressed fluid supports the moving body, and prevents its descending as rapidly as would a spherical bullet, which is constructed to meet the same direct resistance from the air. This trajectory will therefore be more elongated than that of the spherical bullet in question.

Remedied by
the grooves.

But the resistance of the air, acting upon the groove of the projectile, produces, on the lower part of this groove, an action which tends to bring back its point upon the trajectory, yet with so little force, that often, in its descent, the projectile turns over, and moves breadthways at ranges of 1000 and 1200 yards. The lower side of the projectile, therefore, moving in the compressed air, and the upper in the rarified air, deviation must ensue, for, as the upper part of the bullet moves from left to right, the bottom must move from right to left. But the lower resistance to the motion of rotation being produced by the friction of the compressed air, is greater than the upper resistance, which depends on the friction of the rarified air. By combining these two resistances, there results a single force, acting from left to right, which produces what Captain Tamisier termed "derivation," and it was to overcome this derivation that this officer proposed the circular grooves to the bullet, which he considered would act, like the feathers of the arrow, to maintain the moving body in its trajectory.

Cause of
deviation.

Remedy.

How to obtain
knowledge of
the bullet's
rotation.
By the arrow.

Use of
feathers on
arrows.

If, however, we would wish to obtain some idea of the rotatory motion of a bullet in its path through the air, let us consider the action of the arrow, and see how it is constructed, so that the resistance of the air should not act in an unfavourable manner. First, nearly all its weight is concentrated at the point, so that its centre of gravity is close to it. At the opposite end feathers are placed, the heaviest of which does not affect the centre of gravity, but gives rise to an amount of resistance in rear of the projectile, and which prevents its ever taking a motion of rotation perpendicular to its longer axis, and keeps it in the direction of its projection. This difficulty which

the arrow finds in changing its direction must concur in preventing its descending so rapidly as it would do were it only to obey the law of gravity, and must therefore render its trajectory more uniform.

Let us, however, now come back to the grooves of Mons. Tamisier, and we shall find that they concur in giving to the bullet the two actions of the resistance of the air, which we have demonstrated with respect to the arrow.

Suppose that such a bullet describes the trajectory M, and A.B. be the position of its axis, it will be seen that the lower part of the bullet re-establishes the air compressed, whilst the upper part finds itself in the rarified air. That, consequently the lower parts of the cannelures are submitted to the direct action of the air's resistance, whilst their upper parts totally escape this action. (Plate 21, fig. 2). The resultant of the air's resistance evidently tends to bring back the point of the moving body, according to the trajectory; but as this action is produced by the pressure of an elastic fluid, it results that the point B, after having been an instant upon the trajectory, will fall below, in virtue of the velocity acquired; but then the upper grooves finding themselves acted on by the action of the air's resistance, this action, joined to its weight, will force the point of the projectile upwards, which will descend to come up again, so that the projectile will have throughout its flight a vertical swing, which is seen distinctly enough in arrows.

Let us connect the suggestion of Robins, with the experiments of Captain Tamisier, to cause the posterior end to act as a rudder to guide the projectile in its true path, as undoubtedly during the descent of a bullet there is a tendency for the centre of gravity to fall first, as the ball of the shuttlecock. In the first Prussian balls, and in those used in the Tige, the centre of gravity being nearer the base, the rear end of these balls have a tendency to fall before the foremost, but this is most undoubtedly counteracted by grooves, while it would be impossible to fire an elongated projectile with its centre of gravity backwards, with any accuracy out of a smooth-bored gun.

Captain Jervis says that these grooves have the effect of improving the accuracy of firing when the bullets are not perfectly homogeneous, is certain, but the British Committee on small arms justly considered that owing to the careful way in which the bullets are made in England by compression, these grooves might be dispensed with.

Almost every conceivable form of projectile, internal and external, have been made and experimented upon. Auxiliaries to expansion have been used, made of metal, horn-wood, and leather, with plugs, screws, or cups divers shapes. Cannelures are used, of varying forms, depth and number.

It has even been attempted to construct bullets upon the screw principle, so that the projectile should receive spirality from the action of the air upon its outer or inner surface, when fired out of a smooth bore musket.

The general characteristics of the European rifles, up to 1850, are a very large calibre, a comparatively light short barrel, with a quick twist, *i.e.*, about one turn in three feet, sometimes using a patch, and sometimes not, the bullet circular, and its front part flattened by starting and ramming down.

Similar effects
on bullet with
grooves.

Effect of
grooves.

Union of
Robins and
Tamisier.

Cannelures
improved
shooting.
Why none in
English bullet
Variety of
forms.
Auxiliaries to
expansion,
various.

Rotation from
smooth bores.

General cha-
racteristics of
modern rifles.

American alterations.

It appears that the introduction of additional weight in the barrel, reduction in the size of the calibre, the constant use of the patch, a slower twist, generally one turn in 6ft., combined with (what is now known to be a detriment) great length of barrel, are exclusively American.

Picket bullet.

A round ended picket (plate 20, fig. 16), was occasionally used in some parts of the States, until the invention of Mr. Allen Clarke, of the flat ended picket, which allows a much greater charge of powder, producing greater velocity, and consequently less variation in a side wind.

**On the comparative merits of rifles
Points in a perfect rifle.**

A rifle may perform first rate at short ranges, and fail entirely at long, while a rifle which will fire well at extreme ranges can never fail of good shooting at short. In fact certain calibres, &c., &c., &c., perform best at certain distances, and in the combinations of a perfect rifle there are certain points to be attended to, or the weapon will be deficient and inferior.

Velocity.

It is desirable to give a bullet as much velocity as it can safely be started with, and the limit is the recoil of the gun, and the liability of the bullets to be upset or destroyed, for as soon as this upsetting takes place, the performance becomes inferior, and the circle of error enlarged.

Degree of twist.

It is clear that a bullet projected with sufficient twist to keep it steady in boisterous and windy weather, must of necessity have more twist than is actually necessary in a still favourable time; hence a rifle for general purposes, should always have too much twist rather than too little.

Weight of bullet.

The weight of the bullet must be proportioned to the distance it is intended to be projected with the greatest accuracy; for it is a law, that with bodies of the same densities, small ones lose their momentum sooner than large ones. It would be madness to use a bullet ninety to the pound at nine hundred yards, merely because it performed first rate at two hundred yards; or a forty to the pound at two hundred yards, because it performed well at nine hundred yards. The reason is that a forty to the pound cannot be projected with as much velocity at two hundred yards, as the ninety to the pound can, because the ninety uses more powder in proportion to the weight of the bullet than the forty does. Again, the heavier bullet performs better than the lighter one at nine hundred yards, simply because the momentum of the light ball is nearly expended at so long a range as nine hundred yards, and its rotatory motion is not enough to keep it in the true line of its flight, whereas a heavy bullet, having from its weight more momentum, preserves for a longer distance the twist and velocity with which it started.

Calibre.

As weight of projectile is a leading element in obtaining accuracy at long ranges, and as the weight cannot be increased beyond a certain limit in small arm ammunition, hence a small bore is an indispensable requisite for a perfect rifle.

Result of Mr. Whitworth's experiments.

In the foregoing brief summary of the most important properties which should be possessed by a first class rifle, we have dealt in generalities, but we shall now record the experience of Mr. Whitworth, who has entered into the most minute details, and has pointed out the harmony which should subsist between the twist, bore, &c., and the projectile, in the combinations of a perfect rifle.

Premising, that when Mr. Whitworth was solicited by the late honored Lord Hardinge to render the aid of his mechanical genius to the improvement or perfecting a military weapon, he was restricted as to length of barrel, viz., 3 feet 3-in., and weight of bullet, .530 grains. We shall now proceed and use Mr. Whitworth's words.

Bore and weight limited.

"Having noticed the form (hexagonal) of the interior which provides the best rifling surfaces, the next thing to be considered is the proper curve which rifled barrels ought to possess, in order to give the projectile the necessary degree of rotation."

Consideration for curve.

"With the hexagonal barrel, I use much quicker turn and can fire projectiles of any required length, as with the quickest that may be desirable they do not 'strip.' I made a short barrel with one turn in the inch (simply to try the effect of an extreme velocity of rotation) and found that I could fire from it mechanically—fitting projectiles made of an alloy of lead and tin, with a charge of 35 grains of powder they penetrated through seven inches of elm planks."

Hexagonal form admits of quick turn.

After many experiments, in order to determine the diameter for the bore and degree of spirality, Mr. Whitworth adds: "For an ordinary military barrel, 39 inches long, I proposed a .45-inch bore, with one turn in 20 inches, which is in my opinion the best for this length. The rotation is sufficient with a bullet of the requisite specific gravity, for a range of 2000 yards." Under these conditions the projectiles on leaving the gun would be about two and a half diameters of the bore in length. The gun responds to every increase of charge, by firing with lower elevation, from the service charge of 70 grains up to 120 grains; this latter charge is the largest that can be effectively consumed, and the recoil then becomes more than the shoulder can conveniently bear with the weight of the service musket.

Degree of spiral fixed.

Diameter of bore determined.

"The advocates of the slow turn of one in 6 feet 6 inches, consider that a quick turn causes so much friction as to impede the progress of the ball to an injurious and sometimes dangerous degree, and to produce loss of elevation and range; but my experiments show the contrary to be the case. The effect of too quick a turn, as to friction, is felt in the greatest degree when the projectile has attained its highest velocity in the barrel, that is at the muzzle, and is felt in the least degree when the projectile is beginning to move, at the breech. The great strain put upon a gun at the instant of explosion is due, not to the resistance of friction, but to the *vis inertiae* of the projectile which has to be overcome. In a long barrel, with an extremely quick turn, the resistance offered to the progress of the projectile is very great at the muzzle, and although moderate charges give good results, the rifle will not respond to increased charges by giving a better elevation. If the barrel be cut shorter, an increase of charge then lowers the elevation."

Advocates of slow turn.

Effects of quick turn.

"The use of an increasing or varying turn is obviously injurious, for besides altering the shape of the bullet, it causes increased resistance at the muzzle, the very place where relief is wanted."

Objections to increasing spiral.

Length and spiral increased.

"Finding that all difficulty arising from length of projectiles, is overcome by

Diameter
decreased.
Trajectory
lowered.

Proper pow-
der for ex-
panding
bullets.
Powder for
hardened
bullets.

Consequences
of imperfect
expansion.
Advantages
of hexagonal
form.

Mr. Whit-
worth's claims

"giving sufficient rotation, and that any weight that may be necessary can be obtained
"by adding to the length, I adopted for the bullet of the service weight, an increased
"length, and a reduced diameter, and obtained a comparatively low trajectory; less
"elevation is required, and the path of the projectile lies more nearly in a straight
"line, making it more likely to hit any object of moderate height within range, and
"rendering mistakes in judging distances of less moment. The time of flight being
"shortened, the projectile is very much less deflected by the action of the wind."

"It is most important to observe that with all expanding bullets proper powder
"must be employed. In many cases this kind of bullet has failed, owing to the use of
"a slowly igniting powder, which is desirable for a hard metal projectile, as it causes
"less strain upon the piece, but is unsuitable with a soft metal expanding projectile,
"for which a quickly igniting powder is absolutely requisite to insure a complete
"expansion, which will fill the bore. Unless this is done the gases rush past the
"bullet between it and the barrel, the latter becomes foul, the bullet is distorted, and
"the shooting must be bad. If the projectiles used be made of the same hexagonal
"shape externally as the bore of the barrel internally, that is, with a mechanical fit,
"metals of all degrees of hardness, from lead, or lead and tin, up to hardened steel
"may be employed, and slowly igniting powder, like that of the service may be
"employed."

Mr. Whitworth does not lay claim to any originality as inventor of the polygo-
nal system, but merely brings it forward, as the most certain mode of securing spiral
motion, but he deserves to be honored by all Riflemen, as having established the
degree of spirality, the diameter of bore, to ensure the best results from a given weight
of lead, and length of barrel.

CONCLUSION.

In achieving the important position obtained by the rifle in the present day, it has
nevertheless effected no more than was predicted of it by Leutman, the Academician
of St. Petersburg, in 1728, by Euler, Borda, and Gassendi, and by our eminent but
hitherto forgotten countryman Robins, who in 1747, urgently called the attention of
the Government and the public to the importance of this description of fire-arm as a
military weapon.

In the War of American Independence, the rifle, there long established as the
national arm for the chase, exhibited its superiority as a *war* arm also, in so sensible a
manner, that we were constrained to oppose to the American hunters the subsidised
Riflemen of Hesse, Hanover, and Denmark.

We shall close by quoting the last words in "Robins' Tracts of Gunnery."

"Whatever State shall thoroughly comprehend the nature and advantages of rifled
"barrel pieces, and having facilitated and completed their construction, shall introduce
"into their armies their *general* use with a *dexterity* in the *management* of them; they

Robins'
prophecy.

“will by this means acquire a superiority, which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms; and will perhaps fall but little short of the wonderful effects which histories relate to have been formerly produced by the first inventors of fire-arms.”

NOTE.—The preceding articles on the Rifle, Rifling, and Rifle Projectiles are mainly compiled from: “New Principles of Gunnery, by Robins,” “Scloppetaria,” “Remarks on National Defence, by Col. the Hon. A. Gordon,” “Dean’s Manual of Fire Arms,” “Rifle Ammunition, by Capt. A. Hawes,” “Rifles and Rifle Practice, by C. M. Wilcox,” “Papers on Mechanical Subjects, by Whitworth,” “The Rifle Musket, by Capt. Jarvis, Royal Artillery,” “Des Armes Rayees, by H. Mangeot,” “Cours Elementaire sur les Armes Portatives, by F. Gillion,” and “Cours sur les Armes a feu Portatives, by L. Panot.”

THEORETICAL PRINCIPLES.

DEFINITIONS.

Matter.	Matter,—everything which has weight.
Body.	Body,—a portion of matter limited in every direction.
Mass.	Mass,—the quantity of matter in any body.
Particle.	Particle,—or material point, is a body of evanescent magnitude, and bodies of finite magnitude are said to be made up of an indefinite number of particles, or material points.
Inertia.	Inertia,—passiveness or inactivity.
Attraction.	Attraction,—a fundamental law of nature, that every particle of matter has a tendency to be attracted towards another particle.
Density.	Density,—is in proportion to the closeness of the particles to each other.
Volume.	Volume,—the space bounded by the exterior surface of a body, is its apparent volume or size.
Elasticity.	Elasticity,—a body that yields to pressure, and recovers its figure again ; hence air and gasses are elastic bodies ; lead a non-elastic body.
Motion.	Motion,—is the changing of place, or the opposite to a state of rest.
Velocity.	Velocity,—is the rate of motion ; there are four rates of motion, viz., Uniform, Variable, Accelerated, and Retarded.
1st. Uniform	1st. Uniform,—when a particle traverses equal distances, in any equal successive portion of time.
2nd. Variable.	2nd. Variable,—when the spaces passed over in equal times, are unequal.
3rd. Accelerated.	3rd. Accelerated,—when the distances traversed in equal times are successively greater and greater.
4th. Retarded.	4th. Retarded,—when the distances traversed in equal times are successively less and less.
	Accelération or Retardation, may also be equal or unequal, that is uniform or variable.
Friction.	Friction,—arises from the irregularities of the surfaces which act upon one another.
Force.	Force,—any cause which produces, or tends to produce a change in the state of rest, or of motion of a particle of matter.
Measure of force.	Forces are measured by comparison with weights. Thus any forces which will bend a spring into the same positions as weights of 1lb., 2lbs., 3lbs., &c., are called respectively forces of 1lb., 2lbs., 3lbs., &c., &c.

Momentum,—or quantity of motion. If a body moving at first with a certain velocity is afterwards observed to move with double or triple this velocity, the quantity of motion of the body is conceived to be doubled or tripled, hence the momentum of a body, depends upon its velocity, as the quantity of motion of a body is the product of the velocity by the mass or weight. Momentum.

The elementary principles upon which are based all our reasonings respecting the motions of bodies, are called the “Laws of Motion,” and as arranged by Sir Isaac Newton, are three in number. Laws of motion.

1st. A particle at rest will continue for ever at rest, and a particle in motion will continue in motion uniformly forward in a straight line, until it be acted upon by some extraneous force. 1st Law.

2nd. When any force acts upon a body in motion, the change of motion which it produces is proportional to the force impressed, and in the direction of that force. 2nd Law.

3rd. Action and reaction are equal, and in contrary directions. In all cases the quantity of motion gained by one body is always equal to that lost by the other in the same direction. Thus, if a ball in motion, strikes another at rest, the motion communicated to the latter will be taken from the former, and the velocity of the former be proportionately diminished. 3rd Law.

Centre of Gravity,—is that point at which the whole weight of the body may be considered to act, and about which consequently, the body, when subjected to the force of gravity only, will balance in all positions. Centre of Gravity.

Specific Gravity,—the weight belonging to an equal bulk of every different substance, and is estimated by the quantities of matter when the bulks are the same; or in other words, it is the density that constitutes the specific gravity. It is agreed to make pure rain-water the standard, to which they refer the comparative weights of all other bodies. Lead is about eleven times the weight of the same bulk of water. Specific Gravity.

Initial Velocity is the velocity which a bullet possesses on leaving the muzzle of a gun; and in the speaking of the velocity of bullets fired from the musket now used, you understand 1200 feet per second, for the Initial Velocity. Initial Velocity.

Angular Velocity is the velocity with which the circular arc is described; and depends upon the perpendicular distance of the point from the axis of rotation. Angular Velocity.

Terminal Velocity: if a cannon ball were to be let fall from a very great height, it would by the law of gravity, descend with accelerated motion towards the earth, but as the resistance of the air increases as the squares of velocities, a point would be reached when the resistance would be equal to the force of gravity, from whence it would fall to the earth in uniform motion. Terminal Velocity.

An Eccentric Body, is one whose centre of figure does not correspond with the centre of gravity. Eccentric Body.

MOTION OF A PROJECTILE.

If no force were acting upon the projectile, except the explosive force of gunpowder, it would by the first law of motion, move on for ever in the line in which it was Modified by Gravity and air.

discharged ; this motion is modified by the action of two forces, viz., gravity and the resistance of the air.

As the early cannons were of the rudest construction, and were used only to force open barriers, or to be employed against troops at a very short range, it was a matter of secondary consideration what course the bullet took, indeed it was generally believed, that it flew for some distance in a straight line, and then dropped suddenly. Acting upon this opinion we find that most of the early cannon had a large metal ring at the muzzle, so as to render it the same size as at the breech, and with such as were not of this construction they made use of a wooden foresight which tied on to the muzzle, so as to make the line of sight parallel to the axis, by which they conceived that they might aim more directly at the object which the bullet was designed to hit.

Leonardo da
Vinci, 1452.

The first author who wrote professedly on the flight of a cannon shot was a celebrated Italian Mathematician, named Leonardo da Vinci, who explains his manner of studying phenomena, in order to arrive at safe conclusions, thus : "I will treat of the subject, but first of all I will make some experiments, because my intention is to quote experience, and then to show why bodies are found to act in a certain manner;" and taking as his motto, "Science belongs to the Captain, practice to the Soldier," he boldly asks : "If a bombard throws various distances with various elevations, I ask in what part of its range will be the greatest angle of elevation?" The sole answer is a small drawing of three curves, (plate 20, fig. 3.), the greatest range being the curve about midway between the perpendicular and the horizontal. Yet this small drawing is very remarkable when we come to examine it. In the first place, we see that he recognises the fact that the trajectory is a curve throughout its length; secondly, that a shot fired perpendicularly will not fall again on the spot whence it was fired. Simple as they may seem, these two propositions recognise the force of gravity, resistance of the air, and the rotary motion of the earth.

Tartaglia,
1537.

The next author who wrote on the flight of cannon shot was another celebrated Italian Mathematician, named Tartaglia. In the year 1537, and afterwards in 1546, he published several works relating to the theory of those motions, and although the then imperfect state of mechanics furnished him with very fallacious principles to proceed on, yet he was not altogether unsuccessful in his enquiries, for he determined (contrary to the opinion of practitioners) that no part of the track of a bullet was in a straight line, although he considered that the curvature in some cases was so little, as not to be attended to, comparing it to the surface of the sea, which, although it appears to be a plain, when practically considered, is yet undoubtedly incurvated round the centre of the earth. It was only by an accident he nearly stumbled upon one truth in the theory of projectiles, when he stated that the greatest range obtained by equal forces is at 45° . Calculating that at the angle 0° the trajectory was null, that by raising the trajectory, the range increased up to a certain point, afterwards diminished, and finally became null again when the projective force acted perpendicularly, he concluded that the greatest range must be a medium between these two points, and consequently at 45° .

Others thought that a shot, on leaving the muzzle, described a straight line; that after a certain period its motion grew slower, and then that it described a curve, caused by the forces of projection and gravity; finally, that it fell perpendicularly. Tartaglia seems to have originated the notion that the part of the curve which joined the oblique line to the perpendicular, was the arc of a circle tangent to one and the other.

In the year 1638, Galileo, also an Italian, printed his dialogues, in which he was the first to describe the real effect of gravity on falling bodies; on these principles he determined, that the flight of a cannon shot, or of any other projectile, would be in the curve of a parabola, unless it was deviated from this track by the resistance of the air. A parabola is a figure formed by cutting a cone, with a plain parallel to the side of the cone.

Galileo, 1638.

GRAVITY.

We will now proceed to consider the course of a bullet, as affected by *two* forces only, viz., 1st. The velocity communicated to it by the explosion of the powder; and 2nd. By the force of Gravity.

Bullet as influenced by powder and gravity only.

The attraction of the earth acts on all bodies in proportion to their quantities of matter.

The difference of time observable in the fall of bodies through the air, is due to the resistance of that medium, whence we may fairly conclude, that if the air was altogether absent, and no other resisting medium occupied its place, all bodies of whatever size, and of whatever weight, must descend with the same speed. Under such circumstances, a balloon and the smoke of the fire would descend, instead of ascending as they do, by the pressure of the air, which, bulk for bulk, is heavier than themselves. A dry leaf falls very slowly, and a piece of gold very rapidly, but if the gold be beaten into a thin leaf, the time of its descent is greatly prolonged. If a piece of metal and a feather are let fall at the same instant from the top of a tall exhausted receiver, it will be found that these two bodies, so dissimilar in weight, will strike the table of the air-pump, on which the receiver stands, at the same instant. Supposing the air did not offer any resistance to the onward course of a projectile, and that the instantaneous force communicated to a bullet, from the explosion of the gunpowder, were to project it in the line A.B. (plate 21, fig. 4.) from the point A., with a velocity that will send it in the first second of time as far as C., then if there were no other force to affect it, it would continue to move in the same direction, and with the same velocity, and at the next second it would have passed over another space, C.D., equal to A.C., so that in the third second it would have reached E., keeping constantly in the same straight line.

If no air, all bodies would fall in same time.

Gold and dry leaf in same time.

But no sooner does the bullet quit the muzzle, than it immediately comes under the influence of another force, called the force of gravity, which differs from the force caused by the explosion of the powder, which ceases to influence the bullet, after it has once communicated to it its velocity.

Bullet under two forces, powder and gravity.

An accelerat-
ing force.

Effect of gra-
vity.

Result of gra-
vity.

Course of the
bullet.

Parabolic
theory.

Gravity is an accelerating force, acting constantly upon, and causing the bullet to move towards the earth, with a velocity increasing with the length of time the bullet is exposed to its influence. It has been found from experiment that this increase of velocity will cause a body to move through spaces, in proportion to the squares of the time taken to pass over the distance. Thus, if a body falls a given space in one second, in two it will have fallen over a space equal to four times what it fell through in the first second, and in the three first seconds it will have fallen through a space equal to nine times that which it fell through in the first second.

The consequence of this principle is, that all bodies of similar figure, and equal density, at equal distances from the earth, fall with equal velocity; and if a body describes a space of 16ft. in the first second of time, it will, in the next second of time, fall *three* times 16, or 48 feet, and thus will have fallen, from the time it first dropped, four times 16 feet, or 64 feet, because 4 is the square of 2, the time the body was falling. In the third second, it will fall 5 times 16 feet, or 80 feet, and these sums collectively, viz., $16 - 48 - 80 = 144$ feet, the whole distance described by the falling body in three seconds of time.

From this it is evident, that instead of moving in a straight line A. B., (plate 21, fig. 5.), the bullet will be drawn from that course.

From the point c., draw c. F., equal to the space that the bullet may be supposed to fall in one second of time, then at the end of the first second of time the bullet will be at F., instead of at c., and will have moved in the direction A. F., instead of A. c.; at the end of the next second it will have fallen a total distance D. G., equal to four times c. F., thus the bullet will have fallen at the end of the third second a distance E. H., equal to nine times c. F., and it will have moved in the line A. F. G. H. instead of the straight line A. B., in which it would have moved, had it not been affected by the force of gravity. The curve A. H., is of the form called a Parabola, and hence the theory is called the "Parabolic Theory." It is founded on the principle that the velocity given to the bullet by the explosion of the gunpowder is continued throughout its course, but this would only be true in vacuo, and is therefore of little value in calculating the real course of the bullet in the air.

ON THE TIME TAKEN TO DRAW A BALL TO THE GROUND BY THE FORCE OF GRAVITY.

If fired with
axis parallel
to the ground.

1st Case. Supposing a ball to be fired when the axis of the piece is parallel to the ground and 16 feet above it, then the projectile will strike the earth in the same length of time that it would have done, had it been rolled out of the muzzle, quite irrespective of the velocity with which it may have been propelled, or the consequent extent of range; that is to say the ball will have reached the point B., (plate 22, fig. 1.), in the same length of time that it would require to fall from the muzzle A., to the earth c.; *i. e.*, in one second.

2nd Case. Were three guns to be fired at the same instant, with their three axes parallel to the horizon as before, and loaded respectively with $\frac{1}{2}$ drn., 1 drn., and $1\frac{1}{2}$ drn. of powder of the same strength, then, although the three initial velocities and

three ranges would consequently all be different, yet the three balls would strike the ground at the same time, *i. e.* at the points B. B. B. in one second. (Plate 21, fig. 2.)

3rd Case. When a ball is fired at an angle of elevation it will reach the earth in the same length of time which it would occupy in falling the length of the sine of the angle of projection; hence supposing F. G. (plate 21, fig. 3.) to be 16 feet, the ball would reach the point G. in one second, irrespective of the distance from D. to G.

If axis at an angle to the ground.

ATMOSPHERE.

Let us now take into our consideration the course of a projectile while under the influence of *three* forces, viz., powder, gravity, and air.

The atmosphere, or sphere of gases, is the general name applied to the whole gaseous portion of this planet, as the term ocean is applied to its liquid, and land to its solid portions.

Why named.

Being much lighter than either land or water, it necessarily floats or rests upon them, and is in sufficient quantity to cover the highest mountains, and to rise nine or ten times their height, to about 45 miles above the sea level, so as to form a layer over the whole surface, averaging probably between forty and fifty miles in thickness, which is about as thick, in proportion to the globe, as the liquid layer adhering to the surface of an orange, after it had been dipped in water.

It consists essentially of two gases, called oxygen and nitrogen, and also contains a variable quantity of aqueous vapour.

Composition of air.

In common with matter in every state, the air possesses impenetrability. It can be compressed, but cannot be annihilated. It has weight, inertia, momentum, and elasticity.

Qualities of air.

In consequence of its weight is its pressure, which acts uniformly on all bodies, and is equal to between 14lbs. and 15lbs. on every square inch of surface at the sea-level.

The first experiments that were made on projectiles, were carried out on the idea that the resistance of the air would not materially affect the track of a bullet which had great velocity. But the moment a body is launched into space, it meets with particles of the air at every instant of its movement, to which it yields part of its velocity, and the air being a constant force, the velocity of the body decreases at every instant from the commencement of its motion.

Early idea of air's resistance.

How air acts.

RESULT OF THE AIR'S RESISTANCE.

It remained for Robins, 1742, in a work then published, to show the real effect of the atmosphere upon moving bodies. He proved by actual experiment, that a 24lb. shot did not range the fifth part of the distance it should have done according to the parabolic theory. If a cannon shot moved in a parabolic curve, then from the

Robins, 1742, showed effect of air's resistance.

Course of ball
was not a
parabola.

known properties of that curve, it was evident that when fired with elevation, the angle of descent of the bullet should have been the same as the angle at which it was projected, and this he showed was not the case in practice. Now Robins acknowledged the opinion of Galileo, as regards the force of gravity, to be correct; he could not therefore attribute to him any miscalculation on the score of gravity. He therefore concluded, that the error of the "parabolic theory" arose from the supposition that the bullet continued to move at the same velocity throughout its course.

Why not a
parabola.

Ballistic
pendulum.

Robins tried a series of experiments by firing at a ballistic pendulum at different distances; the oscillation of this pendulum enabled him to calculate the velocity of the bullet, at the time it struck the pendulum, and by this means he ascertained, that according to his expectations, the bullet moved slower in proportion as it became more distant from the point at which it was fired. This diminution he attributed to the resistance of the air.

Trajectory
more curved
than a para-
bola.

From these considerations it is evident that instead of moving over equal spaces A. C., C. D., D. E., (plate 22, fig. 4), at each succeeding second of time, it will require considerably longer to traverse each succeeding distance, and the force of gravity will consequently have longer time to act upon it, and will have the effect of lowering the bullet much more than it would do according to the "parabolic theory;" moreover it is evident, that as the velocity of the bullet diminishes, the trajectory or path followed by the bullet, will become still more incurvated.

Having now proved the error of the "parabolic theory," Robins began his endeavours to calculate the actual course of the bullet, according to this new theory which he had demonstrated, but this calculation was necessarily attended with great difficulties, for in so doing a number of circumstances had to be considered.

Resultant.

The resultant of the three forces acting on a projectile, (plate 23, fig. 1), viz., gunpowder, gravity, and the resistance of the air, is a motal force, diminishing in velocity at every instant, causing the projectile to describe a curved line in its flight, the incipient point of the curve lying in the axis of the bore of the piece, and its continuation diverging in the direction of the attraction of gravity, till the projectile obeys the latter force alone.

EXPERIMENTS IN FRANCE.

Angle for
greatest
range.

Velocity.

Elevation
giving certain
range.

It is stated by Captain Jervis, R.A., in the "Rifle Musket," that "From experiments made in France, it has been found that the greatest range of the common percussion musket, with spherical bullet fired with the regulation charge, was at 25° ; yet, by theoretical calculation, it should be 45° ; also that the usual velocity was some 500 yards per second, whilst in vacuum it would be 19,792 yards per second."

"At an angle of from 4° to 5° , the real range was about 640 yards; without the resistance of the air, and at an angle of $4\frac{1}{2}^{\circ}$, it would be 3,674, or six times greater."

ON THE EFFECT OF THE RESISTANCE OF THE AIR UPON THE MOTION OF A PROJECTILE.

The effect of the resistance of the atmosphere to the motion of a projectile, is a subject of the greatest importance in gunnery. It has engaged the attention of the most eminent philosophers, and on account of the great difficulty of determining by experiment, the correctness of any particular hypothesis, much difference of opinion is entertained as to the absolute effect of this retarding force upon bodies moving in the atmosphere with great velocities; and although sufficient is known to guide the practical artillerist in that art to which he is devoted, still as a scientific question, it is one of considerable interest, but more on account of the difficulty of its solution, than from its practical importance.

The effect of the air's resistance upon the motion of a projectile.

To our distinguished countryman, Mr. Benjamin Robins, is due the credit of not only being the first practically to determine the enormous effect of the resistance of the air in retarding the motions of military projectiles, but also of pointing out and experimentally proving other facts with regard to this resistance, which will be noticed when considering the subject of the deviation of shot from the intended direction.

Mr. Robins' discoveries.

After him, Dr. Hutton made a great number of experiments upon the same point, viz., the effect of the resistance of the air upon bodies moving in that medium, both with great and small velocities; and the inferences which he drew from these experiments, although not absolutely true, are sufficiently correct for all practical purposes.

Result of Dr. Hutton's experiments.

ON THE RESISTANCE OF A FLUID TO A BODY IN MOTION.

The resistance which a body meets with in its motion through a fluid will depend upon three principal causes, viz:—

1st. Its velocity, and the form and magnitude of the surface opposed to the fluid.

2nd. Upon the density and tenacity of the fluid or cohesion of its particles, and also upon the friction which will be caused by the roughness of the surface of the body.

3rd. Upon the degree of compression to which this fluid, supposed to be perfectly elastic, is subjected, upon which will depend the rapidity with which it will close in and fill the space behind the body in motion.

Circumstances affecting the resistance which a body meets with in its motion in a fluid.

Firstly, with regard to the velocity of the body. It is evident that a plane moving through a fluid in a direction perpendicular to its surface, must impart to the particles of the fluid with which it comes in contact, a velocity equal to its own; and, consequently, from this cause alone, the resistances would be as the velocities; but the number of particles struck in a certain time being also as the velocities, from these two causes combined, the resistance of a fluid to a body in motion, arising from the inertia of the particles of the fluid, will be as the square of the velocity.

The resistance of a fluid to a body as the squares of the velocities.

Secondly, a body moving in a fluid must overcome the force of cohesion of those parts which are separated, and the friction, both which are independent of the

Cohesion of the particles of a fluid, and friction.

velocity. The total resistance then, from cohesion, friction, and inertia, will be partly constant and partly as the square of the velocity.

Result.

The resistances therefore are as the squares of the velocities in the same fluid, and as the squares of the velocities multiplied by the densities in different fluids.

Hitherto, however, we have imagined a fluid which does not exist in nature; that is to say, a *discontinued* fluid, or one which has its particles separated and *unconnected*, and also perfectly non-elastic.

Atmosphere, and its properties bearing on the question of its resistance.

Now, in the atmosphere, no one particle that is contiguous to the body can be moved without moving a great number of others, some of which will be distant from it. If the fluid be much compressed, and the velocity of the moving body much less than that with which the particles of the fluid will rush into vacuum in consequence of the compression, it is clear that the space left by the moving body will be almost instantaneously filled up, (plate 23, fig. 2); and the resistance of such a medium would be less the greater the compression, provided the density were the same, because the velocity of rushing into a vacuum will be greater the greater the compression. Also, in a greatly compressed fluid, the form of the fore part of the body influences the amount of the retarding force but very slightly, while in a non-compressed fluid this force would be considerably affected by the peculiar shape which might be given to the projectile.

Resistance increased when the body moves so fast that a vacuum is formed behind it.

Thirdly. If the body can be moved so rapidly that the fluid cannot instantaneously press in behind it, as is found to be the case in the atmosphere, the resisting power of the medium must be considerably increased, for the projectile being deprived of the pressure of the fluid on its hind part, must support on its fore part the whole weight of a column of the fluid, over and above the force employed in moving the portion of the fluid in contact with it, which force is the sole source of resistance in the discontinued fluid. Also, the condensation of the air in front of the body will influence considerably the relation between the resistances and the velocities of an oblique surface: and it is highly probable that although the resistances to a globe may for slow motions be nearly proportional to the squares of the velocities, they will for great velocities increase in a much higher ratio.

ON THE VELOCITY WITH WHICH AIR WILL RUSH INTO A VACUUM.

The velocity of the rush of air into a vacuum.

Result.

When considering the resistance of the air to a body in motion, it is important that the velocity with which air will rush into a vacuum should be determined; and this will depend upon its pressure or elasticity.

It has been calculated, that air will rush into a vacuum at the rate of about 1,344 feet per second when the barometer stands at 30 inches, so that should a projectile be moving through the atmosphere at a greater velocity than this, say 1,600 feet per second, then would there be a vacuum formed behind the ball, and instead of having merely the resistance due to the inertia of the particles of the air, it would, in addition, suffer that from the whole pressure of a column of the medium, equal to that indicated by the barometer.

UPON THE RESISTANCE OF THE AIR TO BODIES OF DIFFERENT FORMS.

The influence of the form of a body upon the resistance offered to it by a fluid, is a problem of the greatest difficulty; and although the most celebrated mathematicians have turned their attention to the subject, still, even for slow motions, they have only been able to frame strictly empirical formula, founded upon the data derived from practice; while with regard to the resistance at very high velocities, such as we have to deal with, very little light has hitherto been thrown upon the subject.

Difficulties of
the question.

When a body moves in the atmosphere, the particles which are set in motion by the projectile, act upon those in proximity to them, and these again upon others; and also from the elasticity of the fluid, it would be compressed before the body in a degree dependant upon the motion and form of the body. Moreover, the atmosphere itself partakes so much of the nature of an infinitely compressed fluid, as to constantly follow the body without loss of density when the motion is slow, but not when the velocity is great, so that the same law will not hold good for both. In an infinitely compressed fluid (that is, one which would fill up the space left behind the body instantaneously) the parts of the fluid which the body presses against in its motion would instantaneously communicate the pressure received by them throughout the whole mass, so that the density of the fluid would not undergo any change, either in front of the body or behind it, consequently the resistance to the body would be much less than in a fluid partially compressed like the atmosphere; and the form of the body would not have the same effect in diminishing or increasing the amount of resistance.

Compressed
fluid.

When the velocity of a body moving the atmosphere is so great that a vacuum is formed behind it, the action of the fluid approaches to that of the discontinued fluid.

When a
vacuum is
formed be-
hind the ball.

RESULTS OF EXPERIMENTS WITH SLOW MOTIONS.

1st. It appears from the various experiments that have been made upon bodies moving in the atmosphere, that the resistance is nearly as the surface, increasing a very little above that proportion in the greater surfaces.

Resistance in
proportion to
surface.

2nd. That the resistance to the same surface with *different* velocities, is in *slow* motions nearly as the squares of the velocity, but gradually increasing more and more in proportion as the velocities increase.

Resistance as
squares of
velocity.

Rounded and pointed ends suffer less resistance.

Sharp ends not always least resistance.

Form of base affects resistance.

Only proved for slow motions.

Form of hind part.

Best shape for fore and hind part.

Form determined by extent of range.

Form suggested by Sir I. Newton.

Axis of elongated bodies must be fixed.

Advantages of conical bullets.

Disadvantages of conical bullets.

3rd. The round ends, and sharp ends of solids, suffer less resistance than the flat or plane ends of the same diameter. Hence the flat end of the cylinder and of a hemisphere, or of a cone, suffer more resistance than the round or sharp ends of the same.

4th. The sharper ends have not always the smaller resistances; for instance, the round end of a hemisphere has less resistance than the pointed end of a cone, whose angle with the axis is $25^{\circ} 42'$.

5th. When the hinder parts of bodies are of different forms, the resistances are different, though the fore parts are the same. Hence the resistance to the fore part of a cylinder is less than that on the equally flat surface of the cone or hemisphere, owing to the shape of the *base* of the cylinder. The base of the hemisphere has less resistance than the cone, and the round side of the hemisphere less than that of the whole sphere.

The above refers only to *slow* motions, and the results given, from experiments with very small velocities; and it is to be expected, that with very rapid motions the form of the fore, as well as the hind part, of the projectile, will influence the amount of resistance in a much higher degree.

That form for the hind part will be best which has the greatest pressure upon it, when moving with a certain velocity.

The ogivale form seems, from experiment, to fulfil the former condition. The best form for the *hind* part, for *rapid* motions, has not been determined; it may, however, be considered to be of much less importance than the shape of the fore part.

Of course the best form can be determined by extent of range, but deductions from this will depend upon such a variety of circumstances, the effects of some of which must be entirely hypothetical, that the correctness of any formulæ obtained in this manner must be very uncertain.

Sir Isaac Newton, in his "Principia," has given an indication of that form of body, which, in passing through a fluid, would experience less resistance than a solid body of equal magnitude of any other form. It is elongated.

It is plain, however, that the minimum of resistance would not be obtained with a shot of an elongated form, unless the axis can be kept in the direction of the trajectory; as not only will the axis perpetually deviate from the true direction, but the projectile will turn over and rotate round its shorter axis, that is, if fired out of a smooth bore.

Conical bullets have an advantage, from their pointed end, which enables them to pass through the air with greater facility; and for the same reason they are better calculated to penetrate into any matter than spherical ones.

A *solid* bullet cannot be pointed without sending backward the centre of gravity. The sharper the point, the more it is liable to injury, and if the apex of the cone does not lie true, in the axis of the projectile, then such an imperfection of figure is calculated to cause greater deflections in the flight than any injury which a round surface is likely to sustain. In penetrating into solid bodies, it is also important that the centre of gravity should be near its work.

RESISTANCE OF THE AIR, AS AFFECTED BY THE WEIGHT OF PROJECTILES.

Bodies of similar volume and figure overcome the resistance of the air in proportion to their densities. The amount of the air's resistance is in proportion to the magnitude of the surface. Resistance overcome by weight.

The superficial contents of circles are as the *squares* of their diameters. Hence if the ball A. (plate 23, fig. 3) be 2in. in diameter, and the ball B. 4in., the amount of resistance experienced would be as four to sixteen. Contents of circles.

The cubical contents, or weights of spheres, are in proportion to the *cubes* of their diameters. Hence the power to overcome resistance in the balls A and B would be as *eight* to *sixty-four*. Thus the power to overcome resistance increases in much greater proportion than the resistance elicited by increasing the surface. Contents of spheres.

Suppose an elongated body to have the diameter of its cylindrical portion equal to that of the ball A., *i. e.*, E.F. = C.D., (plate 23, fig. 4), and elongated so that its weight should be equal to that of the spherical shot B., it is evident that it would meet equal resistance from the air, to the ball A., having, at the same time, as much power to overcome resistance as the body B. Advantages of elongated bullets.

Elongated balls, by offering a larger surface to the sides of the barrel, are less liable to be affected by any imperfections in the bore; whereas the spherical ball, pressing only on its tangential point, will give to any little hollows, or undulations, wherever they occur.

A spherical ball cannot be expanded into the grooves, unless there be very little windage, except by blows from the ramrod, the gas escaping round the circumference of the ball, and giving it an irregular motion while passing down the barrel; but an elongated projectile can be readily expanded, and the facility of doing so is in proportion to the difference of length between its major and minor axis. Balls cannot be expanded.

Elongated projectiles easily expanded.

DEVIATIONS OF PROJECTILES FROM SMOOTH-BORED GUNS.

Very great irregularities occur in the paths described by projectiles fired from smooth-bored guns. It is a fact well known to all practical artillerymen, that if a number of solid shot or any other projectile be fired from the same gun, with equal charges and elevations, and with gunpowder of the same quality, the gun carriage resting on a platform, and the piece being laid with the greatest care before each round, very few of the shot will range to the same distance; and moreover, the greater part will be found to deflect considerably (unless the range be very short) to the right or left of the line in which the gun is pointed. Causes of deviation of shot.

The causes of these deviations may be stated as follows:—1st, Windage; 2nd, Rotation; 3rd, Wind; 4th, from Rotation of the Earth. Four causes of deviation.

1st CAUSE, WINDAGE.

Windage causes irregularity in the flight of a projectile, from the fact of the elastic

Action from
windage.

False direc-
tion.

Gives rota-
tion.

gas acting in the first instance on its upper portion, and driving it against the bottom of the bore; the shot re-acts at the same time that it is impelled forward by the charge, and strikes the upper surface of the bore some distance down, and so on by a succession of rebounds, until it leaves the bore in an accidental direction, and with a rotatory motion, depending chiefly on the position of the last impact against the bore. Thus should the last impact of a (concentric) shot when fired from a gun be upon the right hand side of the bore, as represented, (plate 23, fig. 5); the shot will have a tendency to deflect to the left in the direction. While at the same time a rotation will be given to it in the direction indicated by the arrows.

2nd CAUSE, ROTATION.

Rotation
without trans-
lation.

Every body may have a twofold motion, one by which it is carried forward, and the other by which it may turn round on an axis passing through its centre, called a motion of rotation.

When a body has only a motion of translation all the particles of which it is composed move with equal swiftness, and also in parallel directions; and by the first law of motion, every particle put in such motion will constantly move with the same velocity in the same direction, unless it be prevented by some external cause.

Rotation.

Rotation and
translation
combined.

By a motion of rotation, a body without changing its place, turns round on an axis passing through its centre of gravity. A body may have at the same time both a progressive and rotatory motion, without either disturbing the other, and one may suffer a change from the action of some external force, while the other continues the same as before.

Force through
centre of
gravity,
causes pro-
gressive mo-
tion only.

If the direction of the force be through the centre of gravity, it causes a progressive motion only, that is, if the body was at rest before, it will move forward in the direction of the impressed force.

Effect of force
on a body in
motion.

If a body had a progressive motion before, then impressed force will cause it to move faster or slower, or to change its direction, according as the direction of this second force conspires with or opposes its former motion, or acts obliquely on its direction.

Rotation not
disturbed by
second force
in direction of
centre of gra-
vity.

If a body, besides its progressive motion had a motion of rotation also, this last will not be changed by the action of a new force passing through the centre of gravity.

Rotation of
force does not
pass through
the centre of
gravity.

If the direction of the force does not pass through the centre of gravity, the progressive motion will be altered, and the body will then also acquire a rotatory motion round an axis passing through the centre of gravity, and perpendicular to a plane passing through the direction of the force and this centre.

CASES BEARING UPON THE FOREGOING THEORY.

When ball is
perfectly
round, centre
of gravity
coincide with
figure, and no
windage.

1st Case. Suppose the ball to be perfectly round, its centre of gravity and figure to coincide, and let there be no windage. In this case the force of the powder not only passes through the centre of gravity of the shot, but proceeds in a direction parallel to the axis of the bore, and there would be but small friction due to the weight of the shot.

2nd Case. But as there is a considerable amount of friction between the bore and the projectile in the case where there is windage, the direction of this force being opposite to that of the gunpowder, and upon the surface of the ball, it will therefore give rotation to the shot.

If windage
then rotation.

3rd Case. Suppose the ball to be perfectly round, but its centre of gravity not to coincide with the centre of figure. In this case the impelling force passes through the centre of the ball, or nearly so, and acts in a direction parallel to the axis of the piece; but if the centre of gravity of the ball lie out of the line of direction of the force of the powder, the shot will be urged to turn round its centre of gravity.

Eccentricity
causes rota-
tion.

The angular velocity communicated to the body will depend, firstly, upon the length of the perpendicular from the centre of gravity upon the direction of the impelling force, and secondly, upon the law of density of the material or the manner in which the metal is distributed. The direction of rotations will depend upon the position of the centre of figure with regard to that of gravity. (Plate 23, fig. 6.)

Angular velo-
city.

Robins remarks, bullets are not only depressed beneath their original direction by the action of gravity, but are also frequently driven to the right or left of that direction by the action of some other force. If it were true that bullets varied their direction by the action of gravity only, then it ought to happen that the errors in their flight to the right or left of the mark, should increase in proportion to the distance of the mark from the firer only.

Robins'
remarks.

But this is contrary to all experience, for the same piece which will carry its bullet within an inch at ten yards, cannot be relied upon to ten inches in one hundred yards, much less to thirty inches in three hundred.

Deflection not
in proportion
to distance.

Now this irregularity can only arise from the track of the bullet being incurvated sideways as well as downwards. The reality of this doubly incurvated track being demonstrated, it may be asked what can be the cause of a motion so different from what has been hitherto supposed.

1st Cause. Is owing to the resistance of the air acting obliquely to the progressive motion of the body, and sometimes arises from inequalities in the resisted surface.

1st cause of
increase, de-
flection.

2nd Cause. From a whirling motion acquired by the bullet round its axis, for by this motion of rotation, combined with the progressive motion, each part of the bullet's surface will strike the air in a direction very different from what it would do if there was no such whirl; and the obliquity of the action of the air arising from this cause will be greater, according as the rotatory motion of the bullet is greater in proportion to its progressive motion; and as this whirl will in one part of the revolution conspire in some degree with the progressive, and in another part be equally opposed to it, the resistance of the air on the fore part of the bullet will be hereby affected, and will be increased in that part where the whirling motion conspires with the progressive; and diminished where it is opposed to it. And by this means the whole effort of resistance, instead of being in a direction opposite to the direction of the body, will become oblique thereto, and will produce those effects we have already mentioned. For instance, if the axis of the whirl was perpendicular to the horizon,

2nd cause,
from whirling
motion.

Direction of a
shot in-
fluenced by
position of
axis round
which it
whirls.

then the incurvation would be to the right or left. If that axis were horizontal to the direction of the bullet, then the incurvation would be upwards or downwards. But as the first position of the axis is uncertain, and as it may perpetually shift in the course of the bullet's flight, the deviation of the bullet is not necessarily either in one certain direction, nor tending to the same side in one part of its flight that it does in another, but it more usually is continually changing the tendency of its deflection, as the axis round which it whirls must frequently shift its position during the progressive motion.

Doubly incur-
vated track.

It is constantly found in practice that a shot will deviate in a curved line, either right or left, the curve rapidly increasing towards the end of the range. This most probably occurs from the velocity of rotation decreasing but slightly, compared with the initial velocity of the shot, or, if a strong wind is blowing across the range during the whole time of flight, the curve would manifestly be increased according as the velocity of the ball decreased.

ILLUSTRATIONS OF ROBINS' THEORY OF ROTATION.

With ball and
double string.

1st Illustration. A wooden ball $4\frac{1}{2}$ inches in diameter suspended by a double string, nine feet long. It will be found that if this ball receive a spinning motion by the untwisting of the string it will remain stationary. If it be made to vibrate, it will continue to do so in the same vertical plane. But if it be made to spin while it vibrates it will be deflected to that side on which the whirl combines with the progressive motion.

By firing
through
screens.

2nd Illustration. By firing through screens of thin paper placed parallel to each other, at equal distances, the deflection or track of bullets can easily be investigated. It will be found that the amount of deflection is wholly disproportioned to the increased distance of the screens.

Bent muzzle.

3rd Illustration. To give further light upon this subject, Mr. Robins took a barrel and bent it at about three or four inches from the muzzle to the left, the bend making an angle of 3° or 4° with the axis of the piece.

By firing at screens it was found that although the ball passed through the first screens to the left, it struck the butt to the right of the vertical plane on which aim was taken in line of the axis of the unbent portion of the barrel. This was caused by the friction of the ball on the right side of the bent part of the muzzle, causing the ball to spin from left to right.

ON ECCENTRIC PROJECTILES.

How to find
centre of gra-
vity.

Sir Howard Douglas, in his "Naval Gunnery," states:—"The position of the "centre of gravity can be found by floating the projectile in mercury, and marking "its vertex. Then mark a point upon the shot diametrically opposite to that point, "which will give the direction of the axis in which the two centres lie. Thus the "shot can be placed in the gun with its centre of gravity in any desired position."

"On making experiments, it appeared that not one shot in a hundred, when floated in mercury, was indifferent as to the position in which it was so floated, but turned immediately, until the centre of gravity arrived at the lowest point, and consequently that not one shot in a hundred was perfect in sphericity, and homogeneity. Shells can be made eccentric by being cast with a solid segment in the interior sphere, left in the shell, or by boring two holes in each shell, diametrically opposite to one another, stopping up one with 5lbs. of lead, and the other with wood. When the centre of gravity was above the centre of the figure, the ranges were the longest, and when below, the shortest. When to the right or left hand, the deviations were also to the right or left. The mean range which, with the usual shot, was 1640 yards, was, with the shot whose centres of gravity and of figure were not coincident, the centre of gravity being upwards, equal to 2140 yards, being an increase of 500 yards."

Effect of
eccentricity.

"With respect to the ricochet of eccentric spherical projectiles, the rotation which causes deflection in the flight, must act in the same manner to impede a straight forward graze. When an ordinary well formed homogenous spherical projectile, upon which probably very little rotation is impressed, makes a graze, the bottom of the vertical diameter first touches the plane, and immediately acquires, by the reaction, a rotation upon its horizontal axis, by which the shot rolls onwards throughout the graze, probably for a straight forward second flight. But in the case of an eccentric spherical projectile, placed with its centre of gravity to the right or to the left, its rotation upon its vertical axis during the graze must occasion a fresh deflection in its second flight, and it is only when the centre of gravity is placed in a vertical plane passing through the axis of the gun, that the rotation by touching the ground will not disturb the direction of the graze, though the extent of range to the first graze will be affected more or less according as the centre of gravity may have been placed upwards or downwards. Whether the rebounds take place from water, as in the experiments made on board the "Excellent," or on land, as those carried on at Shoeburyness, the shot, when revolving on a vertical axis, instead of making a straight forward graze, suffered deflection which were invariably towards the same side of the line of fire as the centre of gravity; and at every graze up to the fourth, a new deflection took place."

Ricochet of
eccentric shot.

"The results of these very curious and instructive experiments fully explain the extraordinary anomalies, as they have heretofore been considered, in length of range and in the lateral deviations: these have been attributed to changes in the state of the air, or the direction of the wind, to differences in the strength of the gunpowder, and to inequalities in the degrees of windage. All these causes are, no doubt, productive of errors in practice, but it is now clear that those errors are chiefly occasioned by the eccentricity and nonhomogeneity of the shot, and the accidental positions of the centre of gravity of the projectile with respect to the axis of the bore. The whole of these experiments furnish decisive proof of the necessity of paying the most scrupulous attention to the figure and homogeneity of solid shot, and concentricity of shells, and they exhibit the remarkable fact that a very considerable

Knowledge
derived from
experiments
with eccentric
shot.

"increase of range may be obtained without an increase in the charge, or elevation of the gun."

No advantage in using eccentric projectiles.

It is not to be expected that eccentric projectiles would be applicable for general purposes, on account of the degree of attention and care required in their service, nor would much advantage be gained by their use, as the momentum is not altered, and it is only necessary to give the ordinary shot a little more elevation in order to strike the same object.

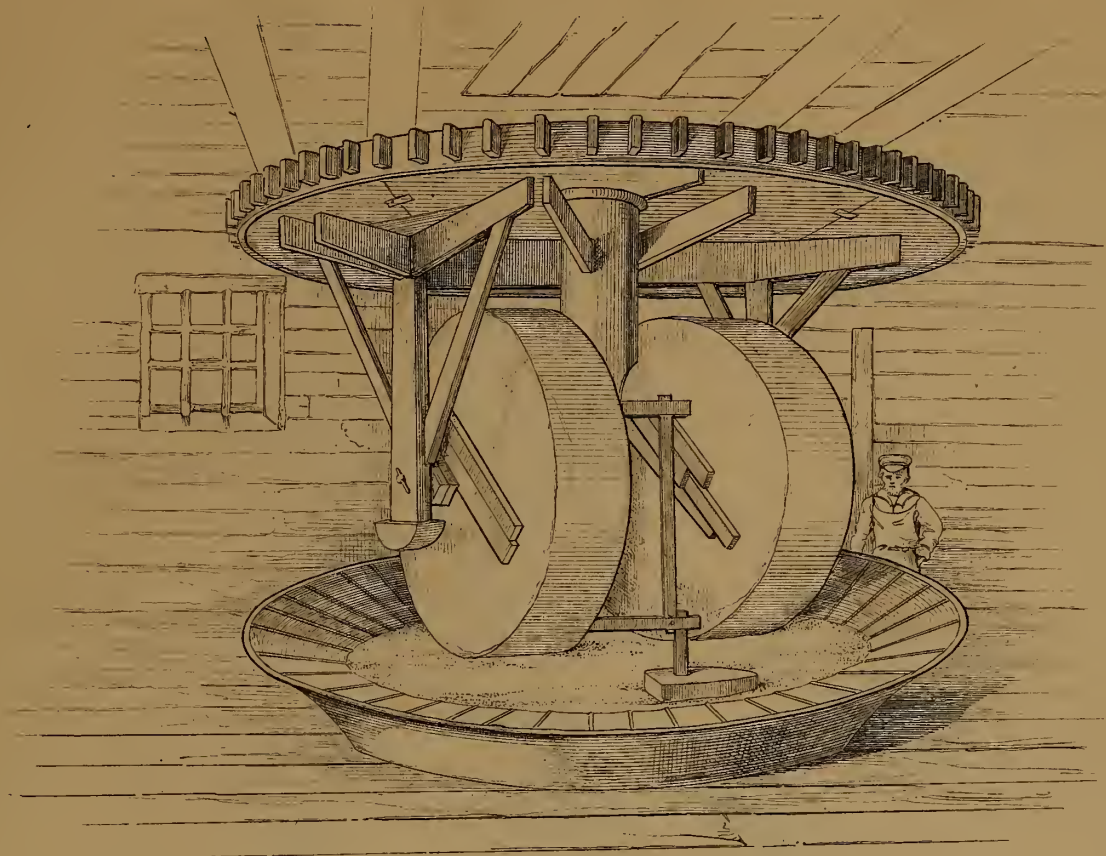
Range of elongated projectiles at certain low elevations greater in air than in vacuo.

There is another point of great importance with regard to the range of elongated projectiles. It is asserted by Sir W. Armstrong and others, that at certain low elevations the range of an elongated projectile is greater in the atmosphere than in vacuo, and the following is the explanation given by the former of this apparent paradox. "In a vacuum, the trajectory would be the same, whether the projectile were elongated or spherical, so long as the angle of elevation, and the initial velocity were constant; but the presence of a resisting atmosphere makes this remarkable difference, that while it greatly shortens the range of the round shot, it actually prolongs that of the elongated projectile, provided the angle of elevation do not exceed a certain limit, which, in my experiments, I have found to be about 6°. This appears, at first, very paradoxical, but it may be easily explained. The elongated shot, if properly formed, and having a sufficient rotation, retains the same inclination to the horizontal plane throughout its flight, and consequently acquires a continually increasing obliquity to the curve of its flight. Now the effect of this obliquity is, that the projectile is in a measure sustained upon the air, just as a kite is supported by the current of air meeting the inclined surface, and the result is that its descent is retarded, so that it has time to reach to a greater distance."

Charge.

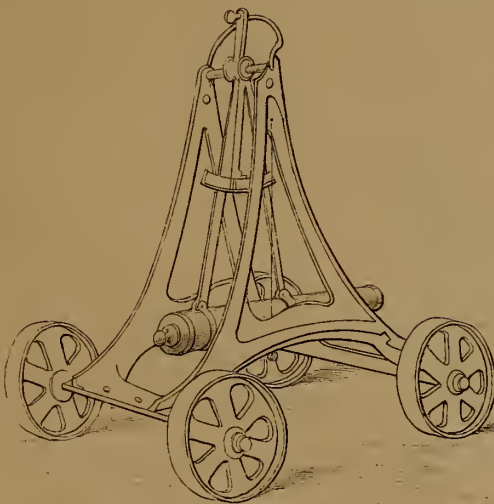
The form and weight of the projectile being determined as well as the inclination of the grooves, the charge can be so arranged as to give the necessary initial velocity, and velocity of rotation; or if the nature of projectile and charge be fixed, the inclination of the grooves must be such as will give the required results. The most important consideration is the weight and form of projectile; the inclination of the grooves, the charge, weight of metal in the gun, &c., are regulated almost entirely by it. The charges used with rifle pieces are much less than those with which smooth-bored guns are fired, for little or none of the gas is allowed to escape by windage, there being therefore no loss of force; and it is found by experience that, with comparatively low initial velocities, the elongated projectiles maintain their velocity, and attain very long ranges.

NOTE.—The foregoing articles on "Theory," are principally extracted from "New Principles of Gunnery by Robins," "Treatise on Artillery, by Lieut.-Colonel Boxer, R.A." "The Rifle Musket, by Captain Jervis, M.P., Royal Artillery." "Elementary Lectures on Artillery, by Major H. C. Owen and Captain T. Dames, Royal Artillery."



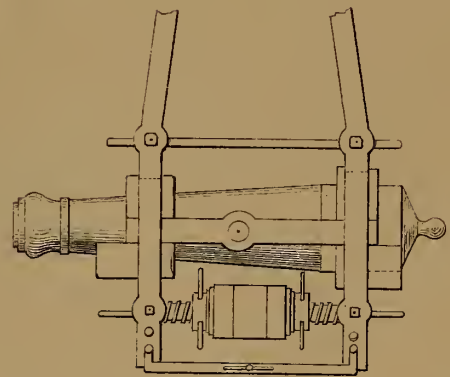
Powder Mill

FIG. 2.

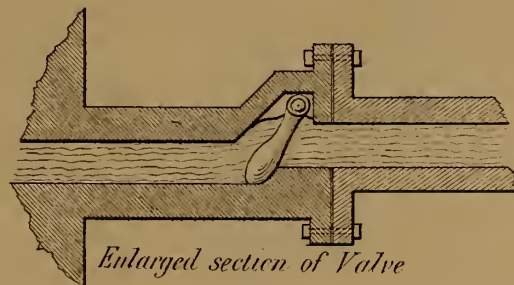
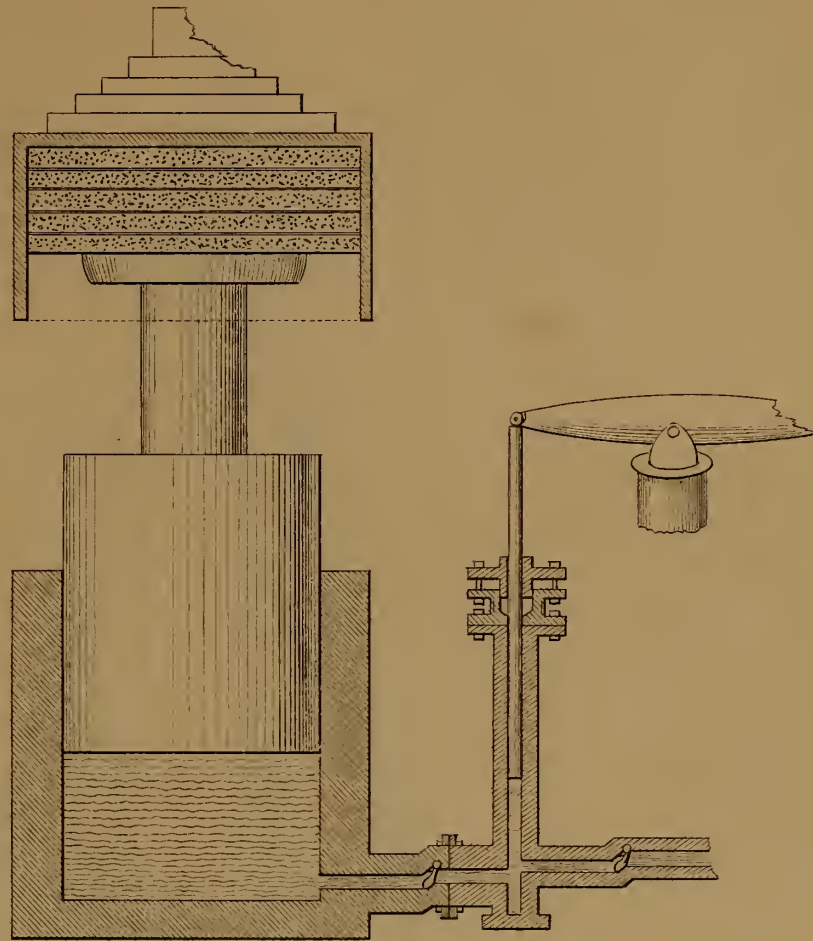


Old Eprouvette Pendulum

FIG. 3.

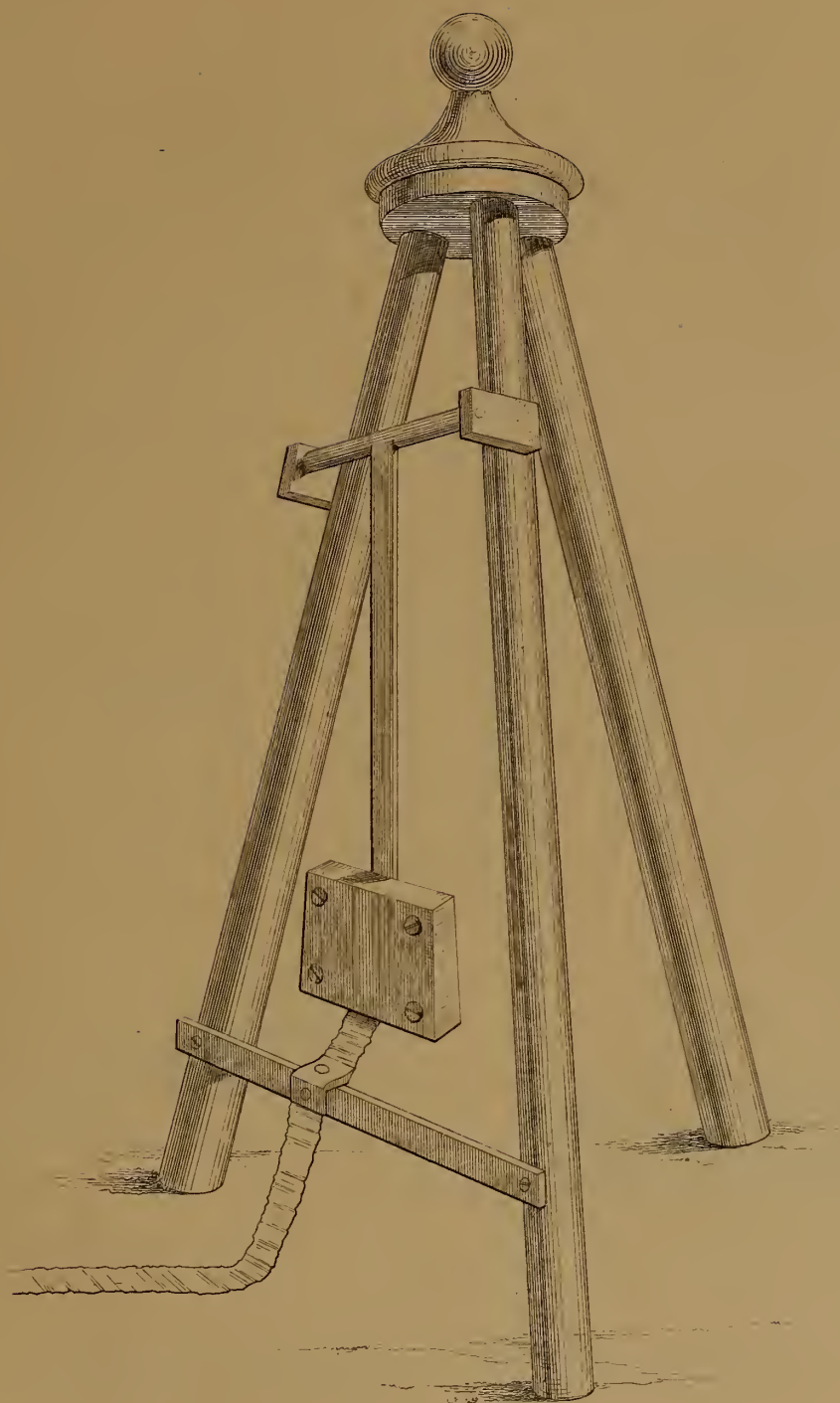


New Pattern Eprouvette



Hydraulic Press

Ha & Son. 6/6



Robins' Balistic Pendulum .

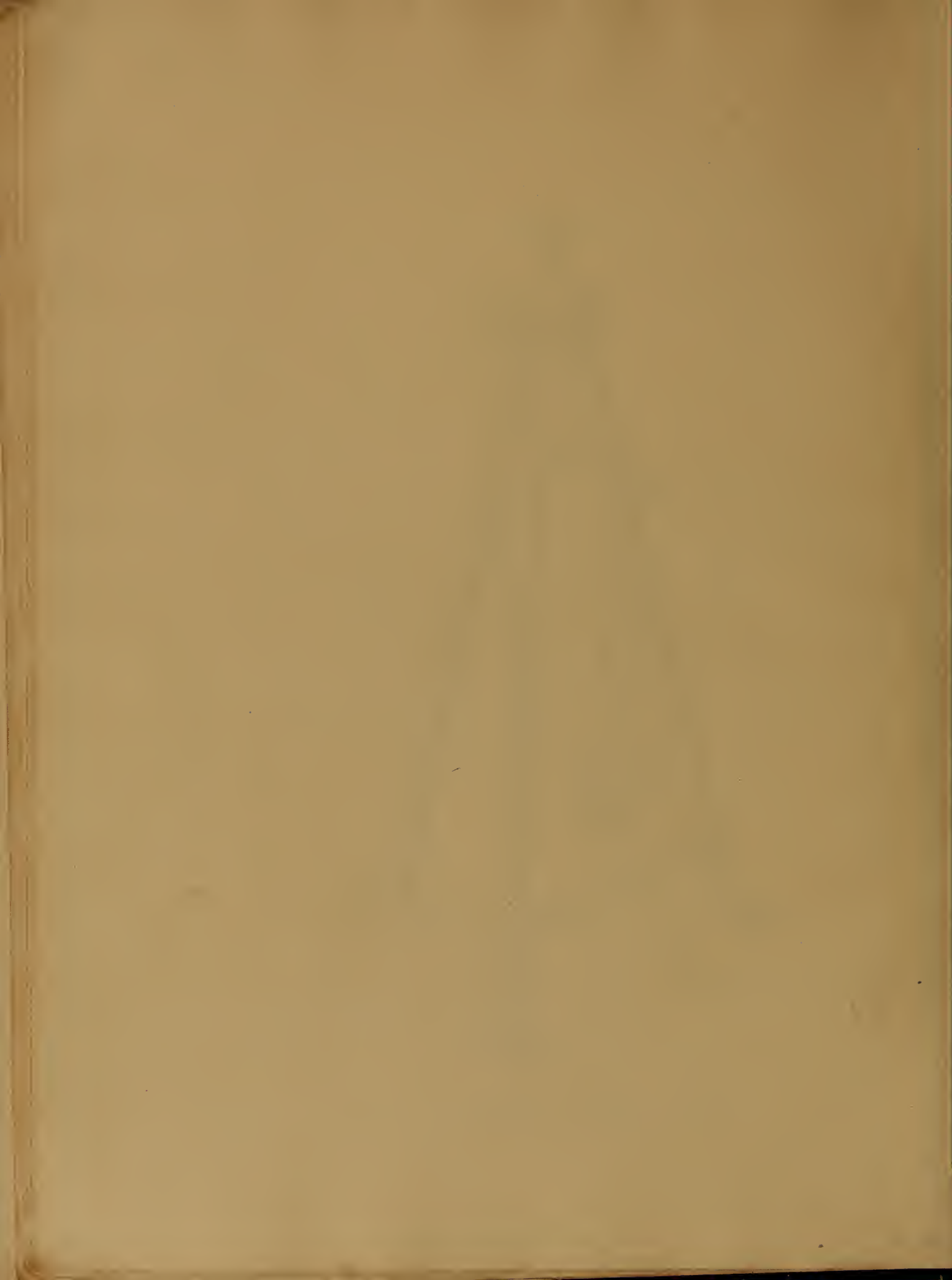
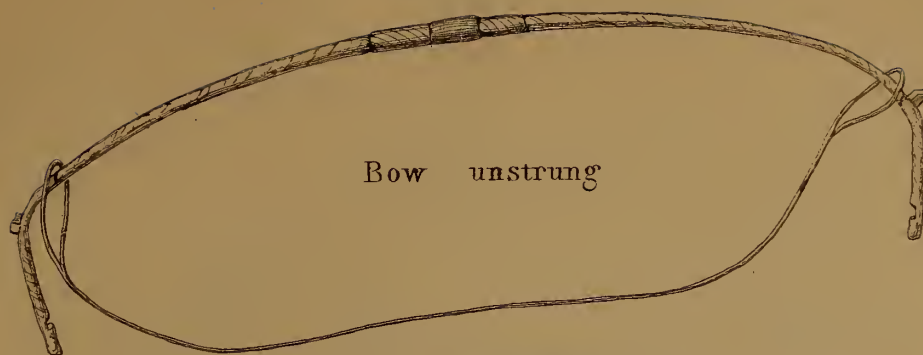
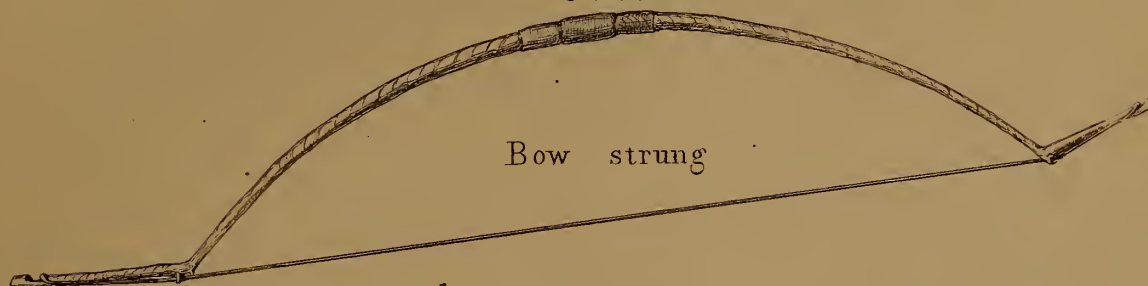


FIG. 1.



Bow unstrung

FIG. 2.



Bow strung

FIG. 3



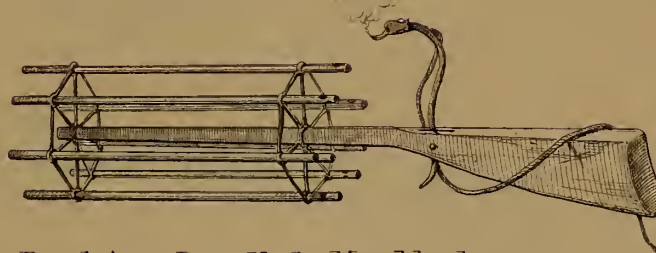
Hand or Arrow Rocket

FIG. 4.



Five barrelled Matchlock

FIG. 5.



Revolving Barrelled Matchlock

CHINESE EXPLOSIVE AND OTHER WEAPONS.

FIG. 6.



Asiatic Bow

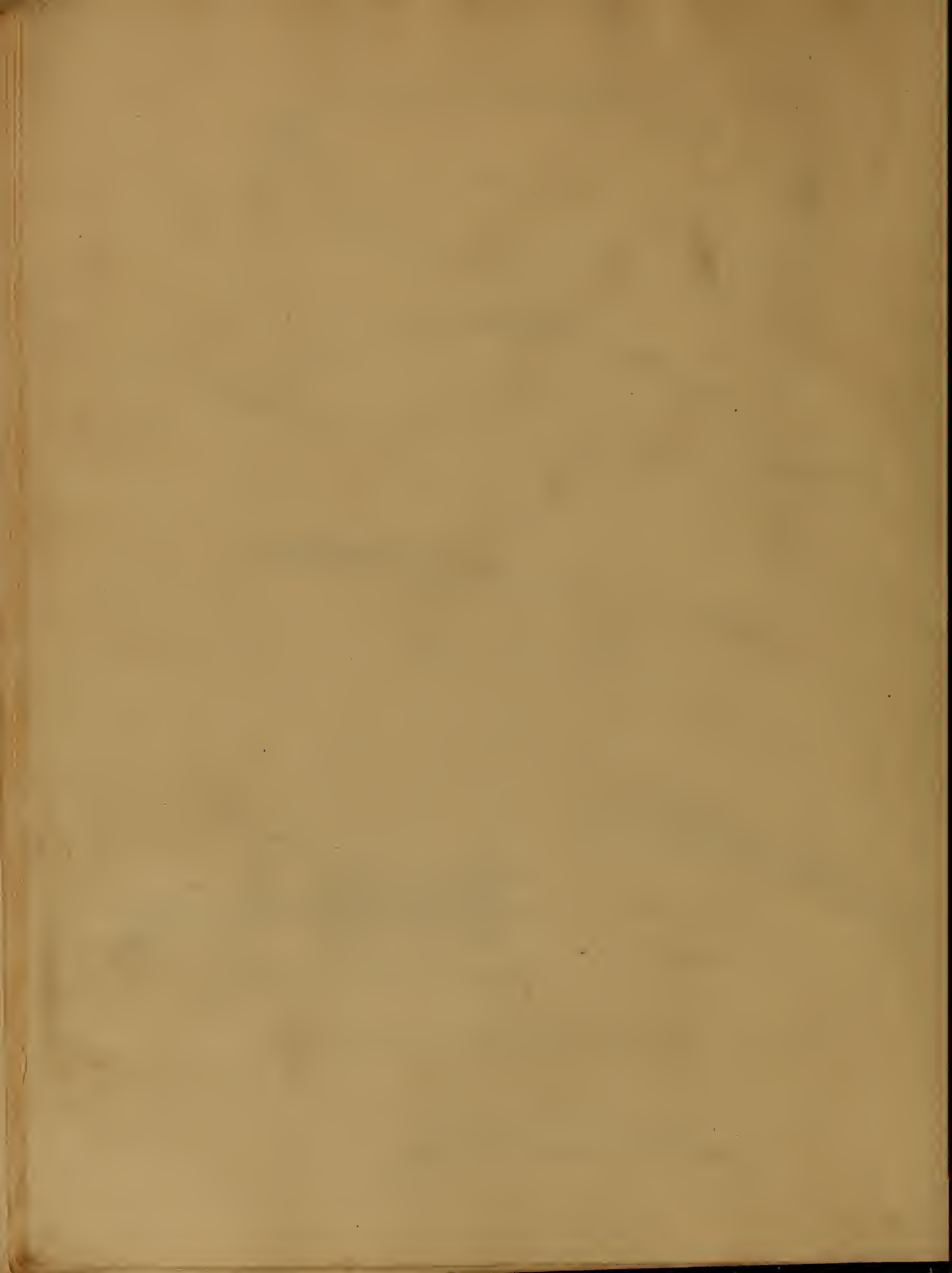
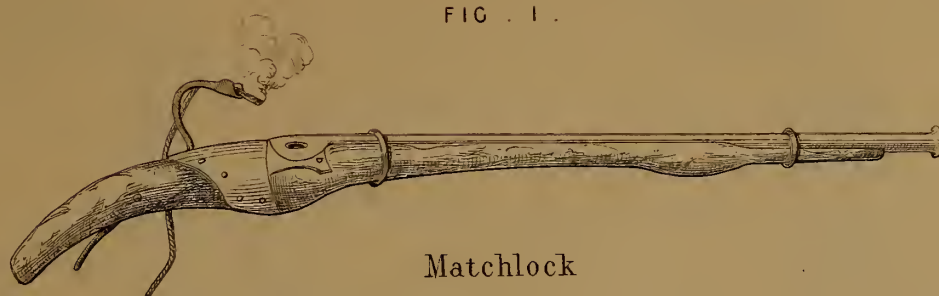
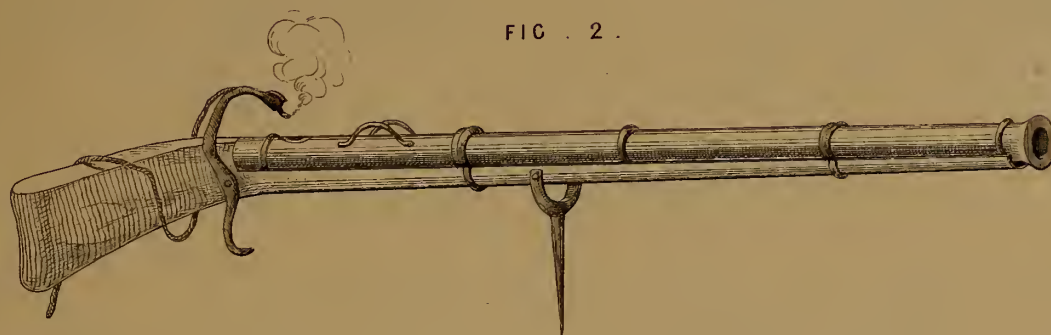


FIG . 1 .



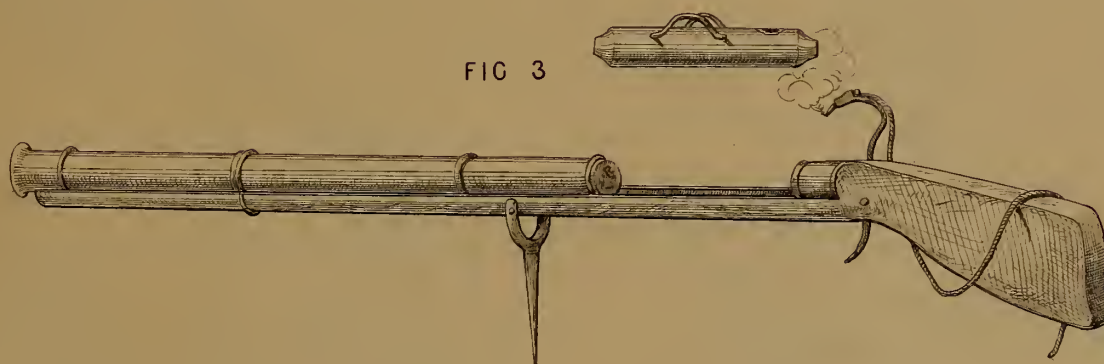
Matchlock

FIG . 2 .



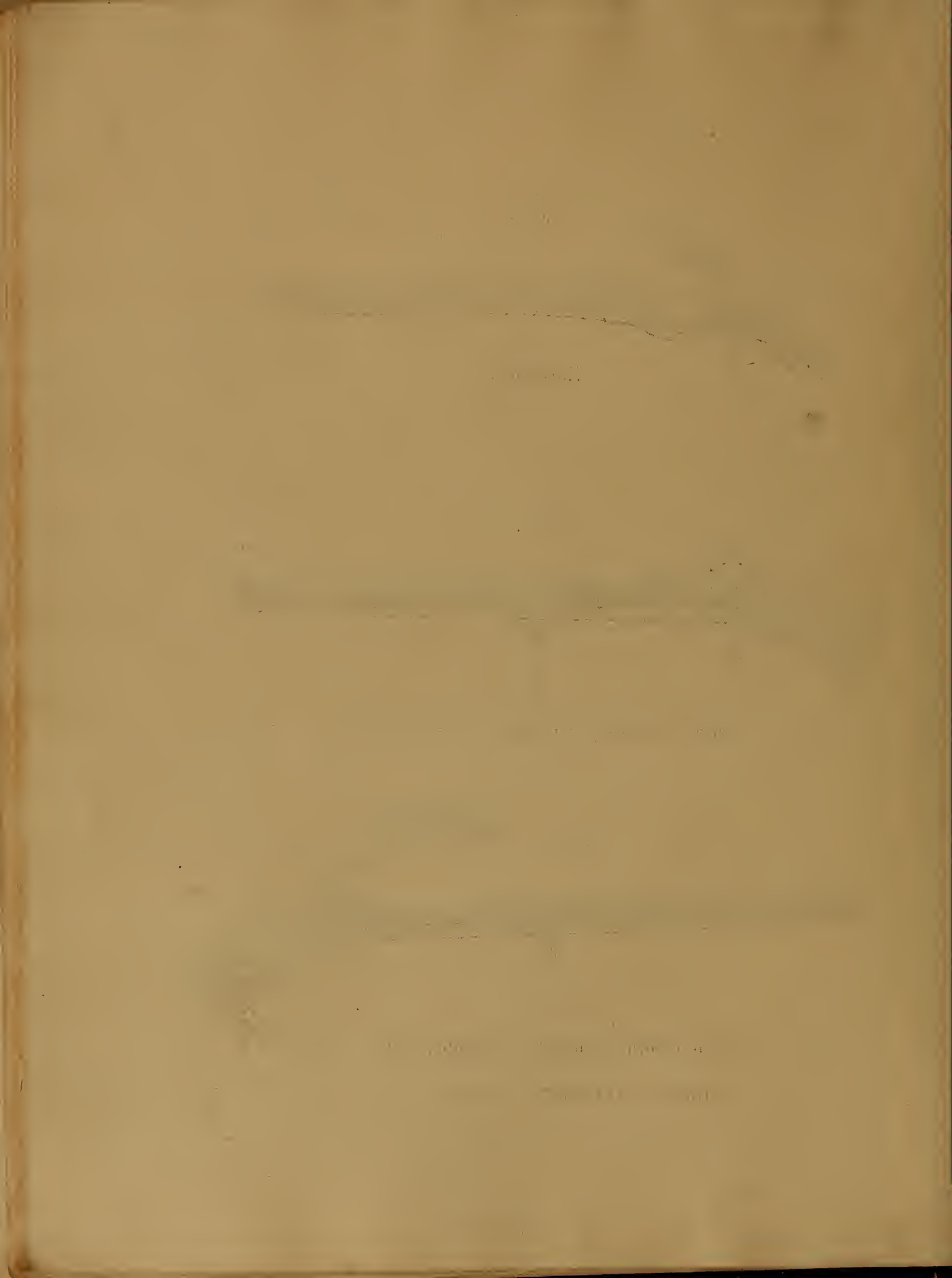
Breech loading Gingal (Chamber in)

FIG 3



Breech loading Gingal (Chamber out)

CHINESE EXPLOSIVE ARMS .



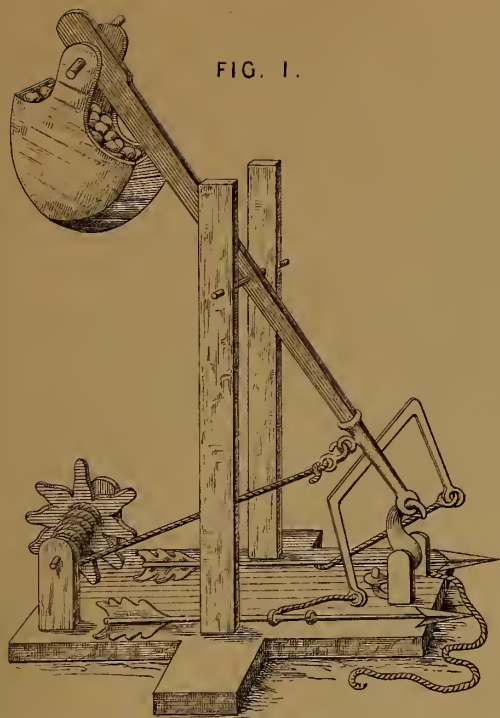


FIG. 1.

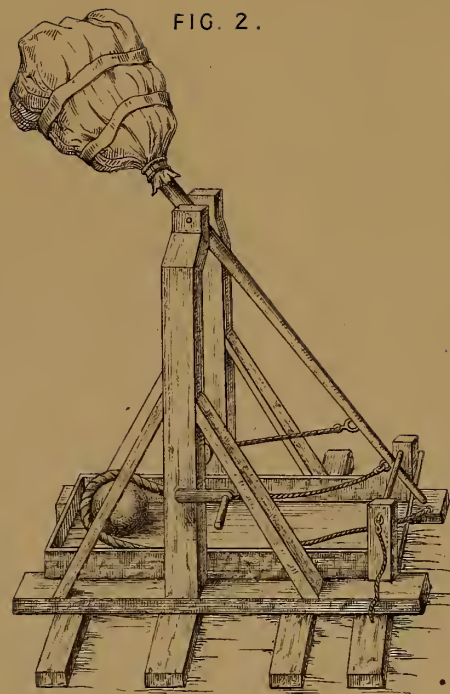


FIG. 2.

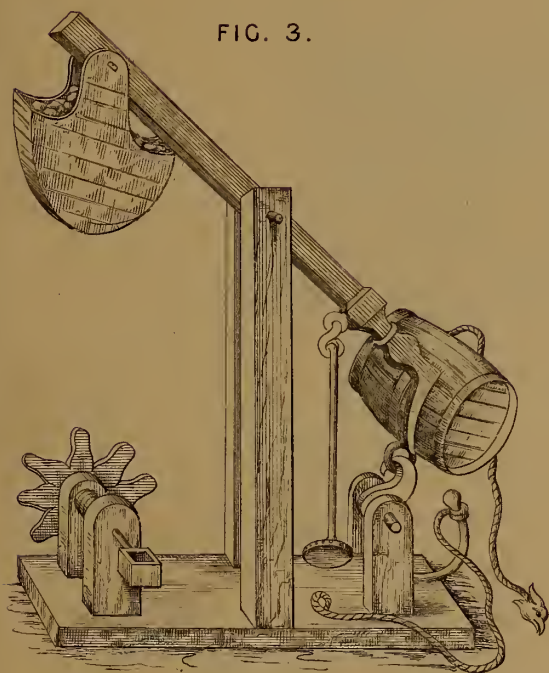


FIG. 3.

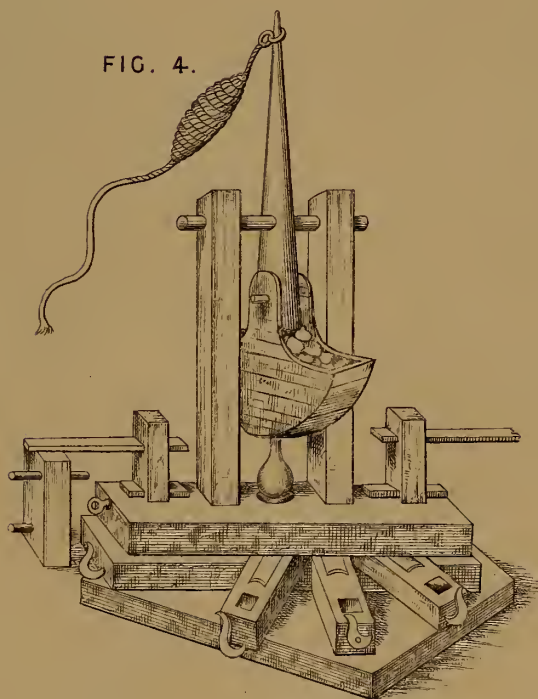
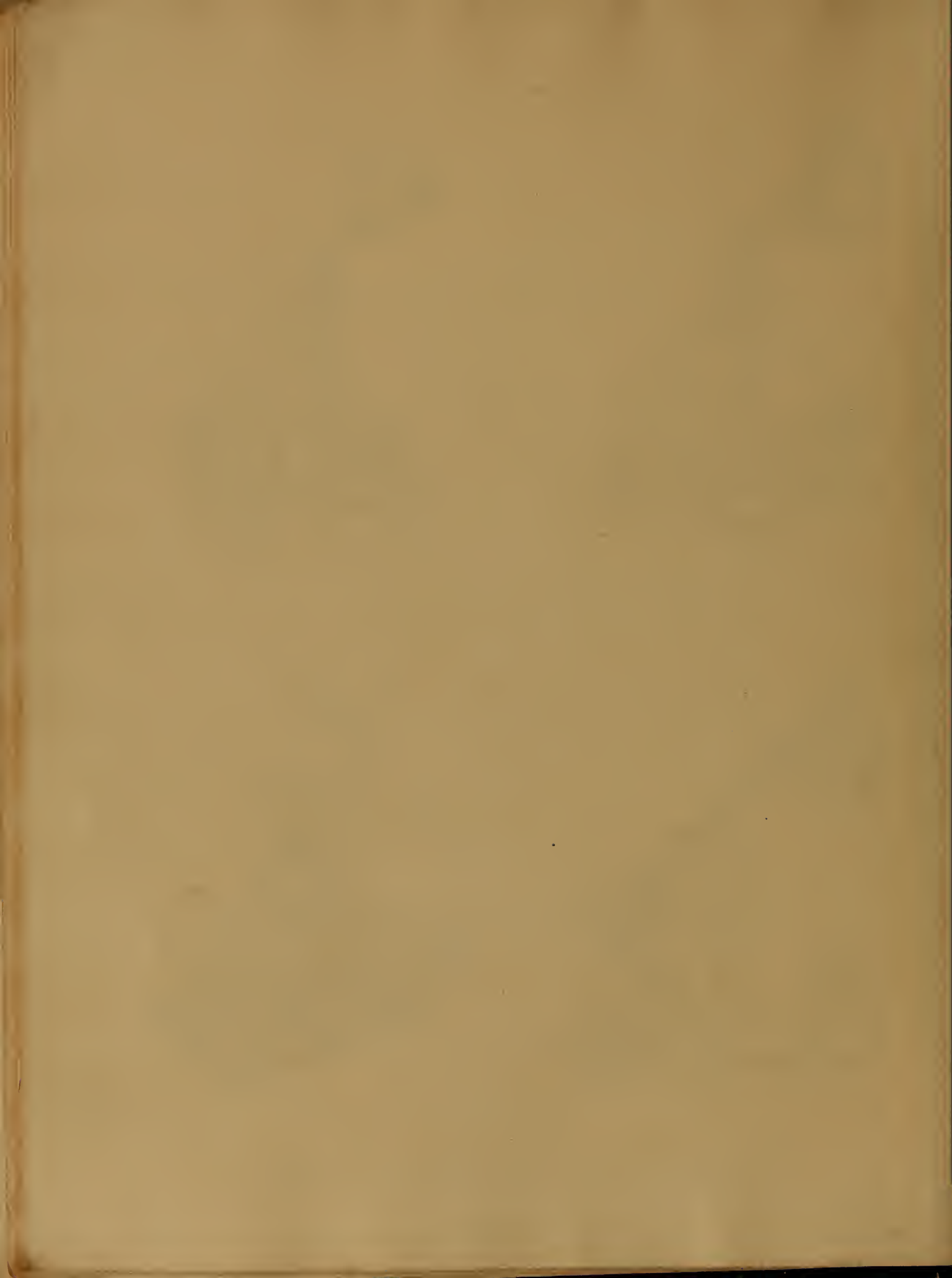


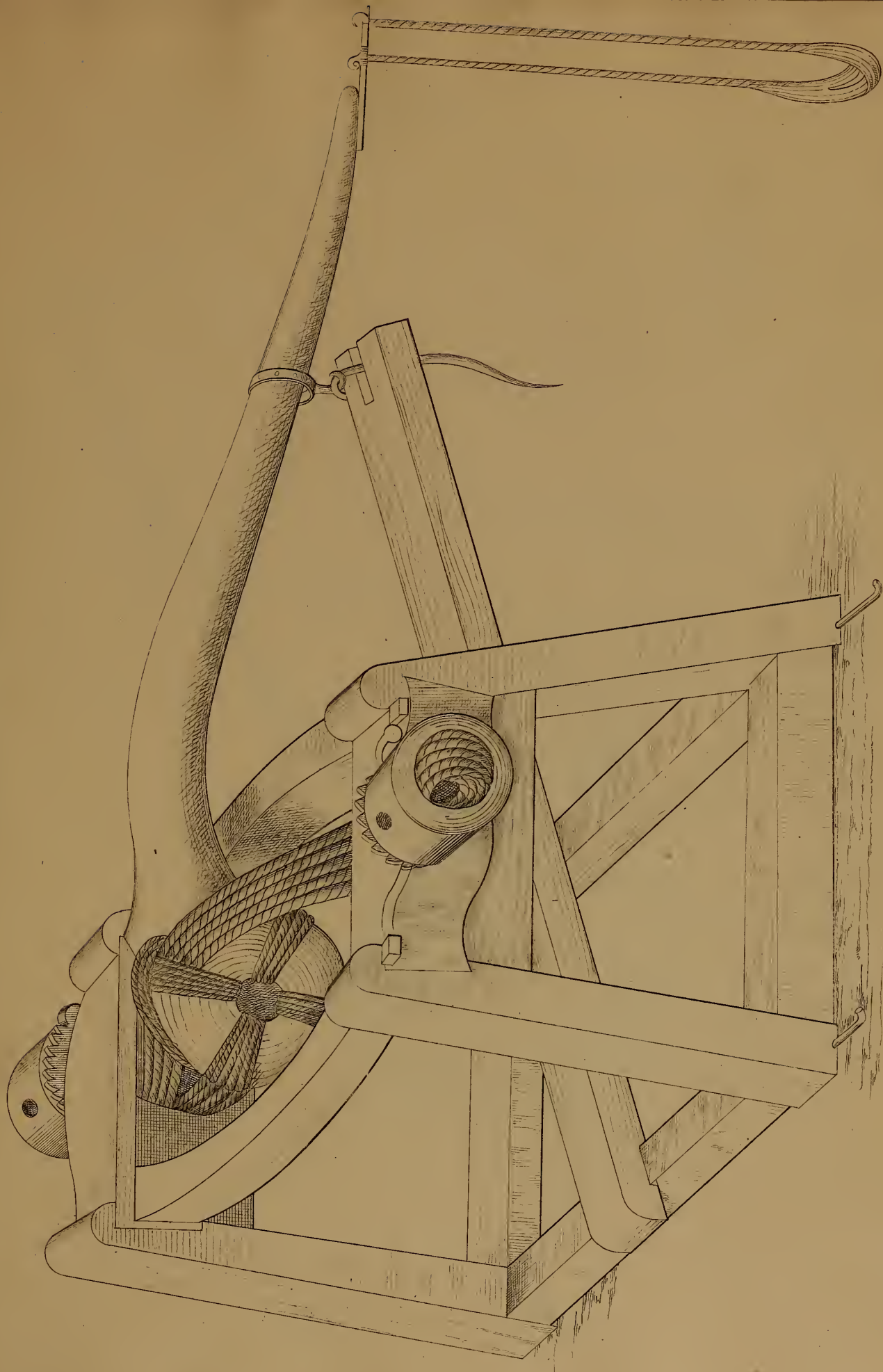
FIG. 4.

Harry Vernon del.

MACHINES FOR THROWING DARTS AND STONES.

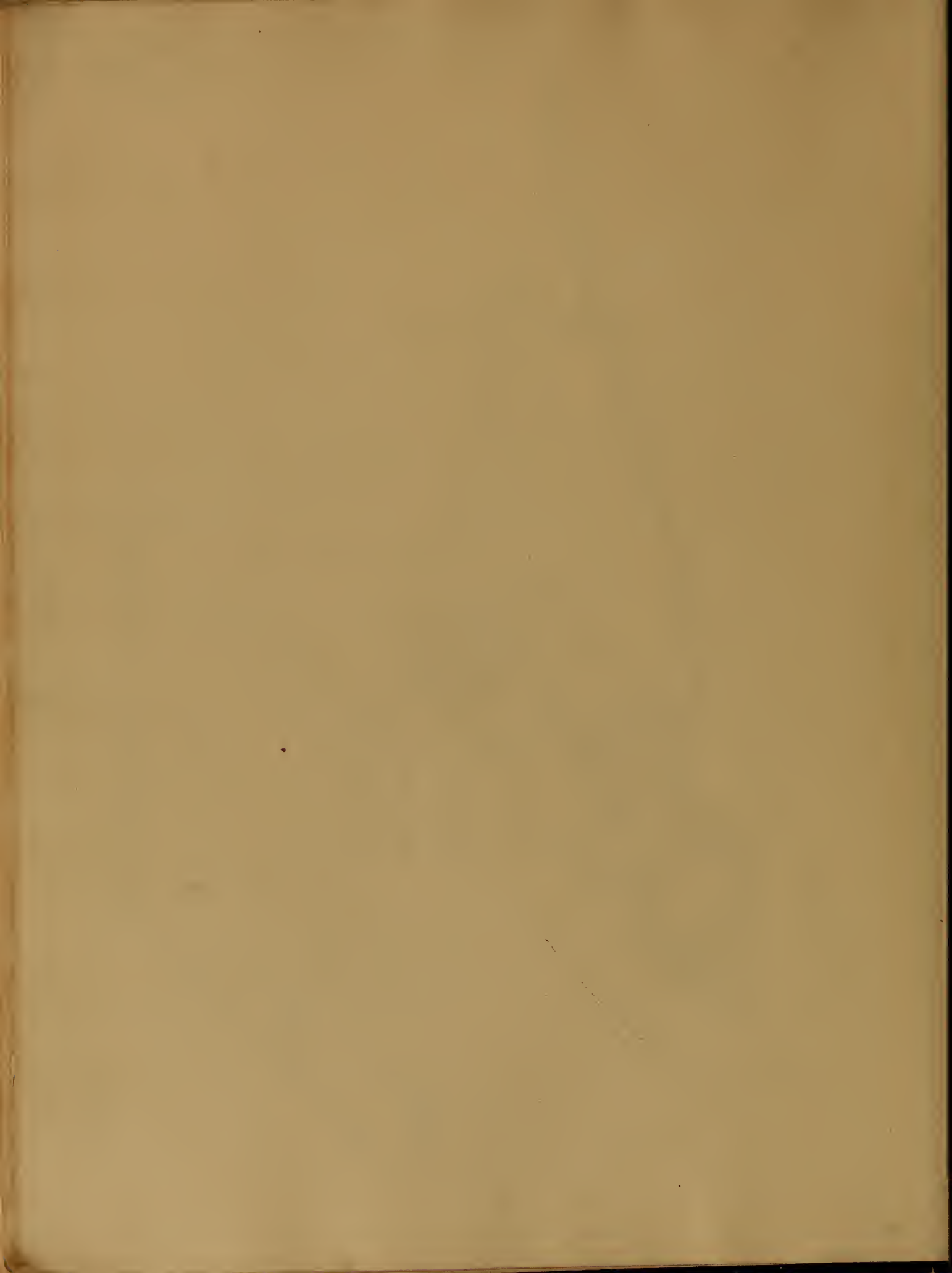


ONAGER (SLUNG).

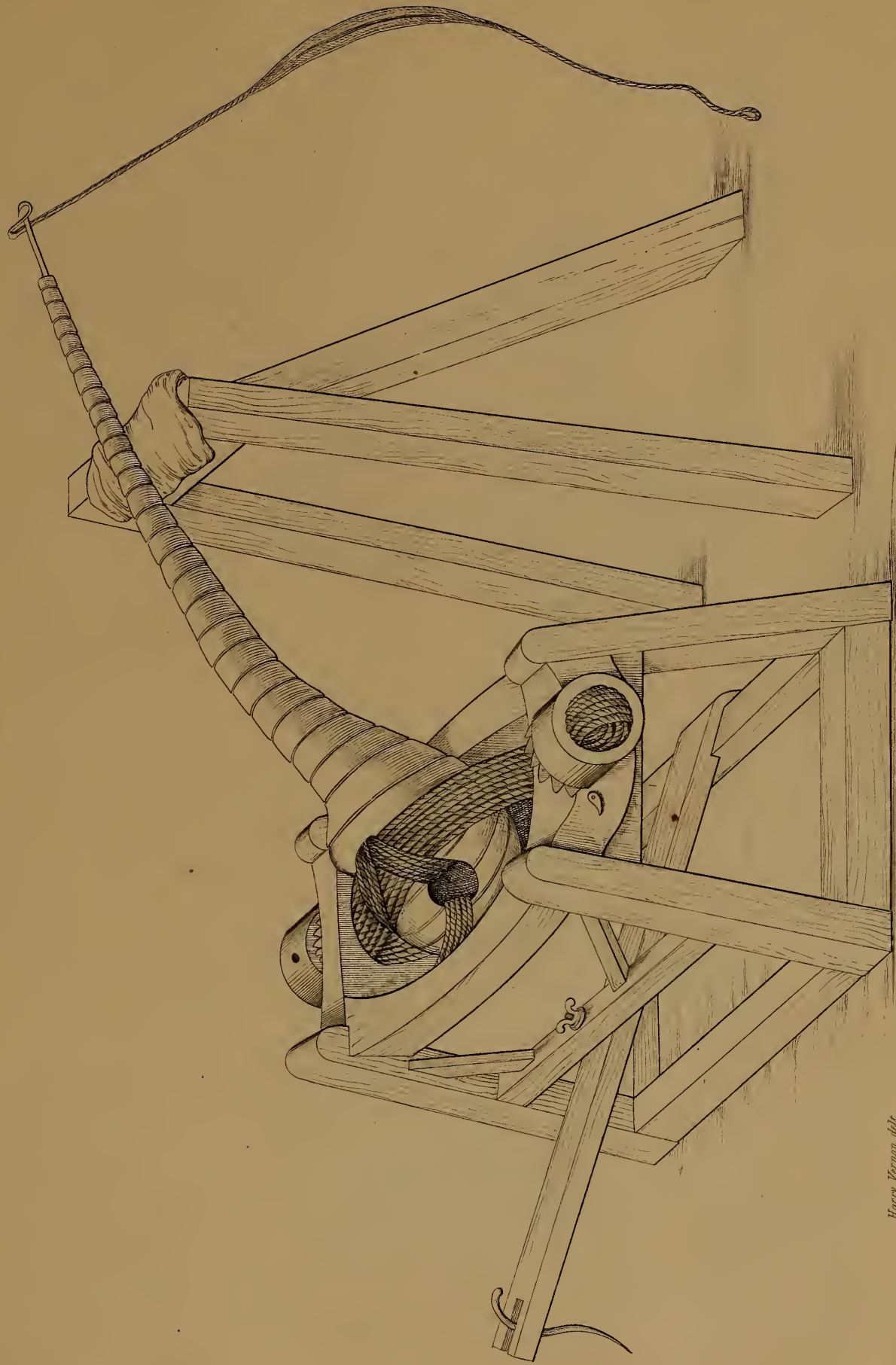


Harry Vernon dell

Day & Son, Ld^{rs} to the Queen



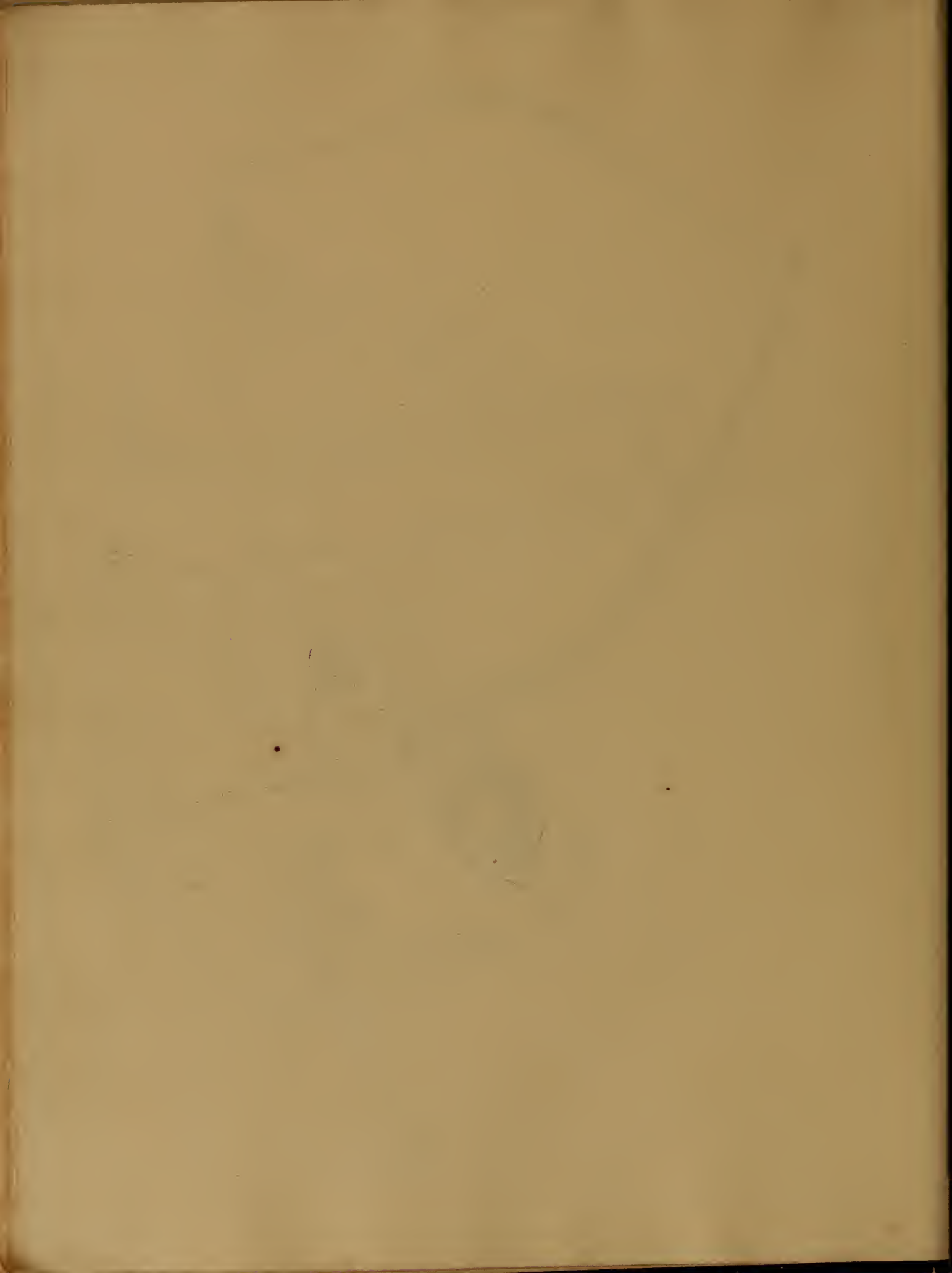
Onager (unslung)



Harry Vernon del.

FEET 6 5 4 3 2 1 0 3 6 9 12 INCHES

Day & Son Lithrs to the Queen.

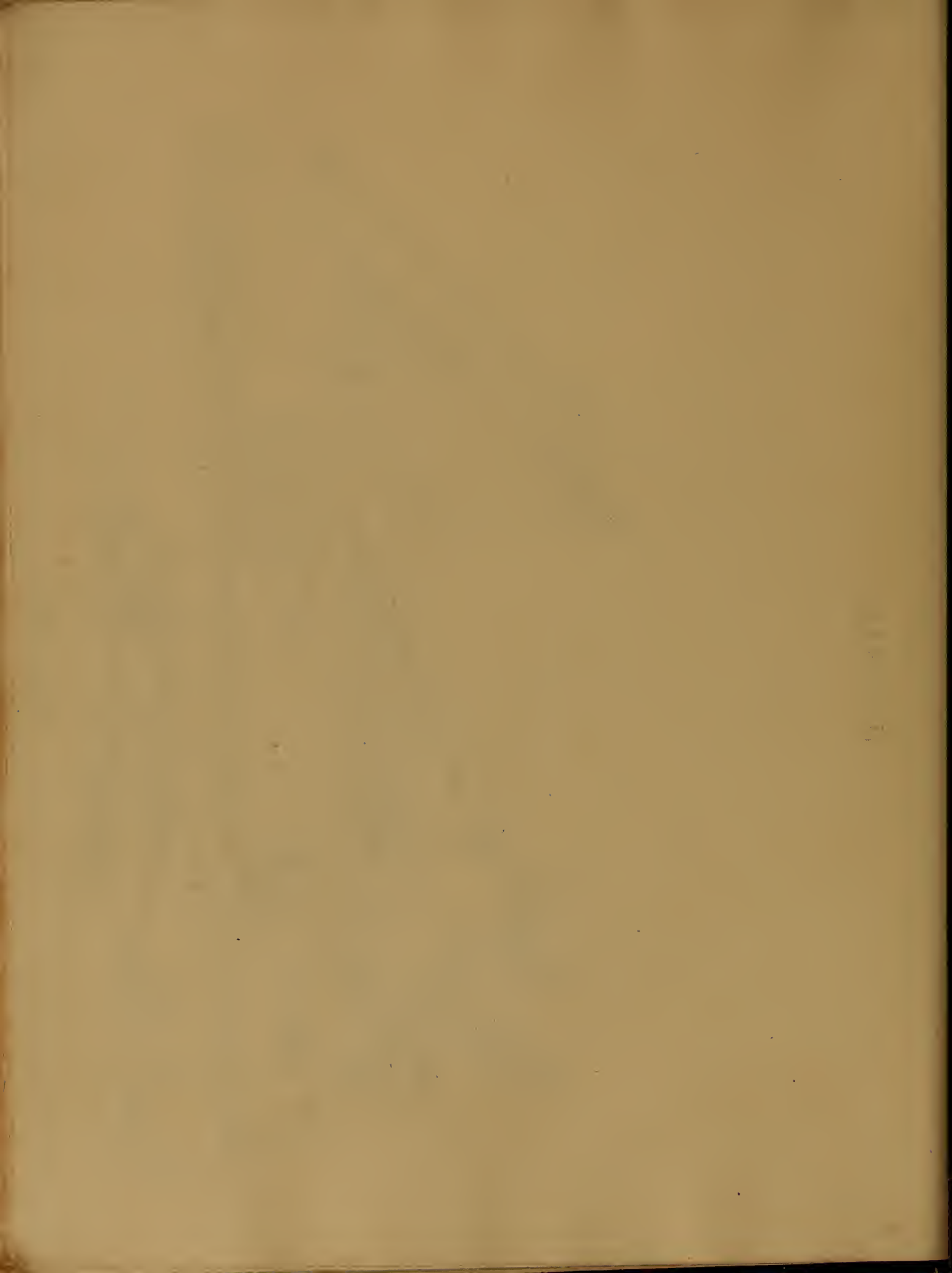


Balista

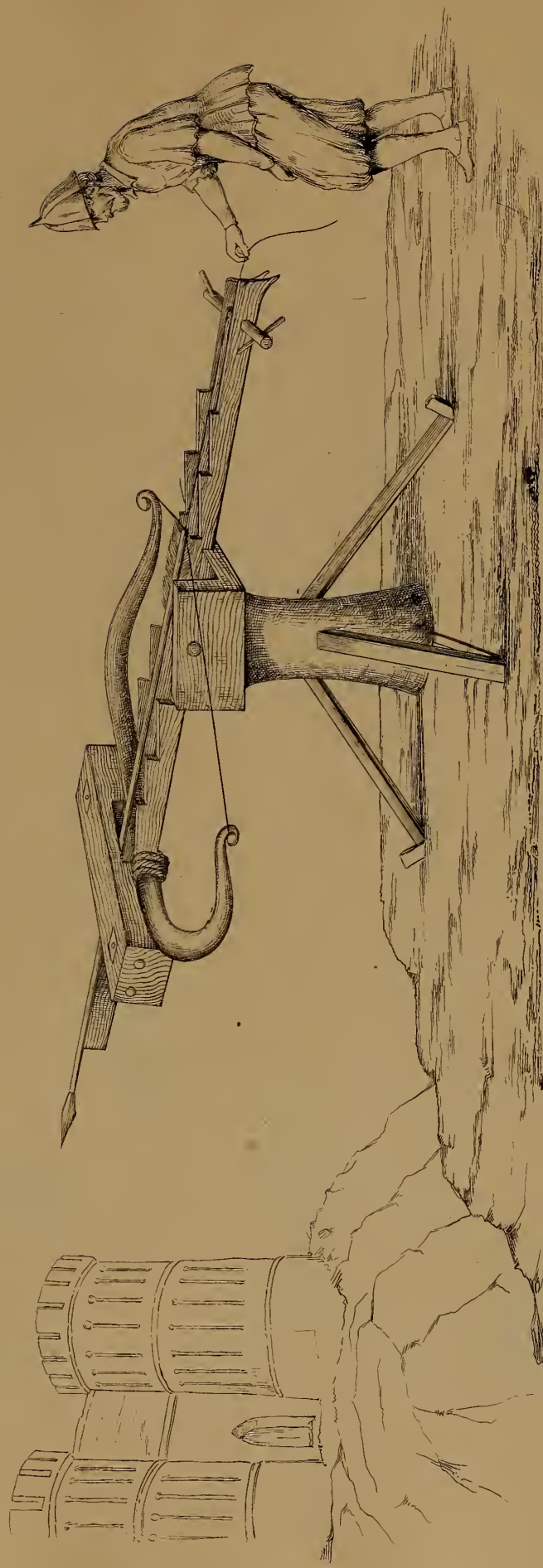


Arthur Waller Ct 79th 21b.

Day & Son Lith^{rs} to the Queen.

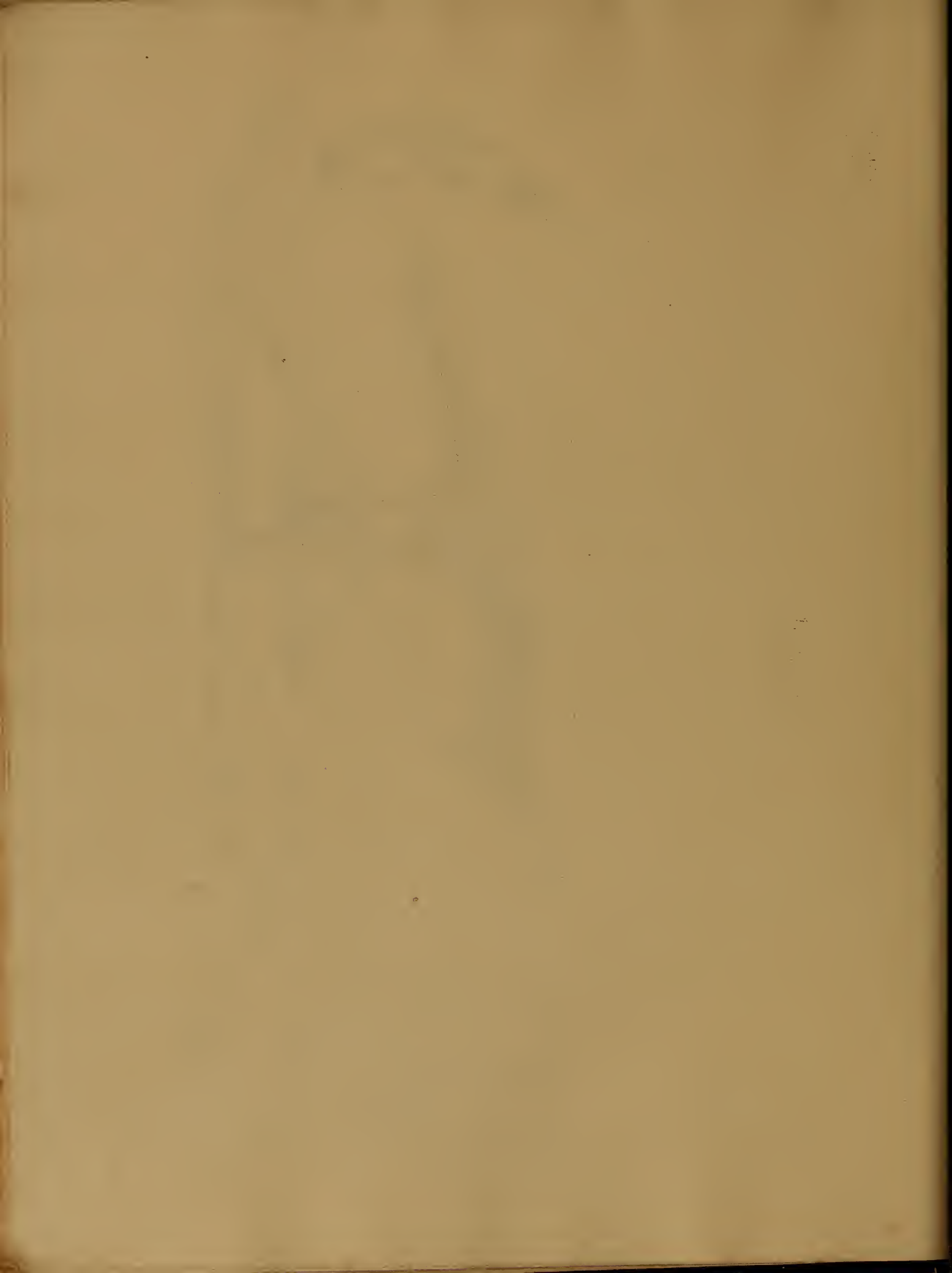


Catapulta.



Dessiné par Arthur Walker.

Day & Son Lithrs to the Queen



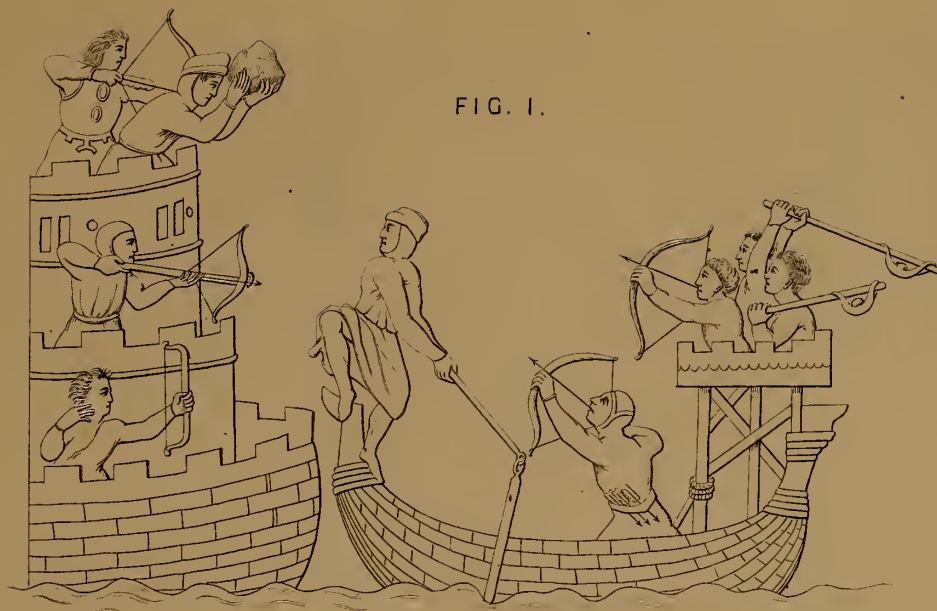


FIG. 1.

Staff slings, Longbows, Crossbows and Flail.

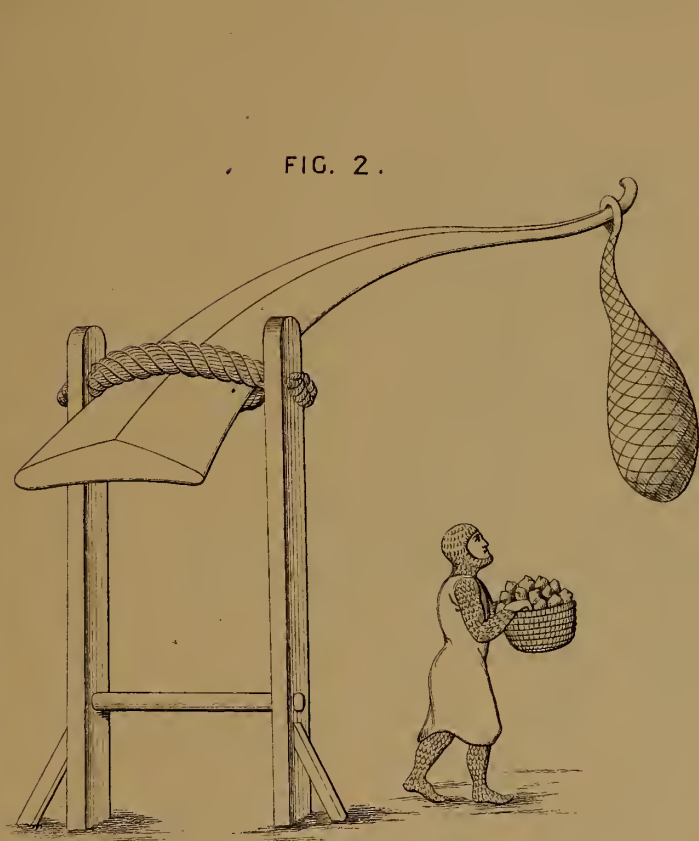


FIG. 2.

Onager.

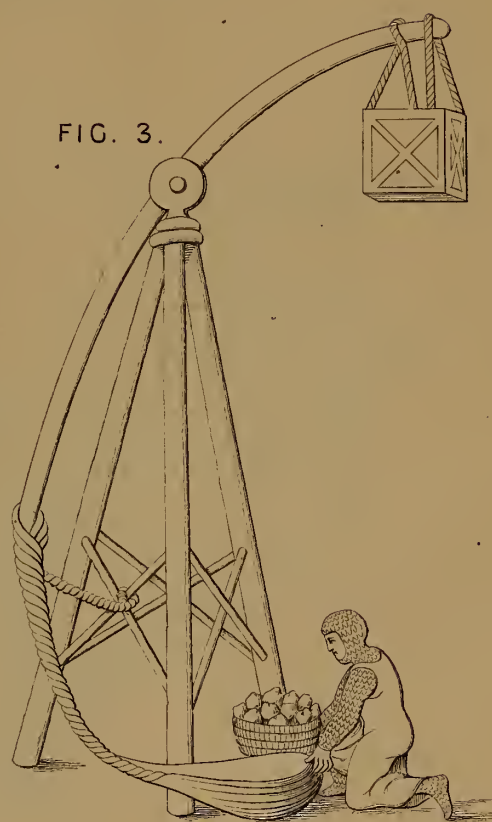
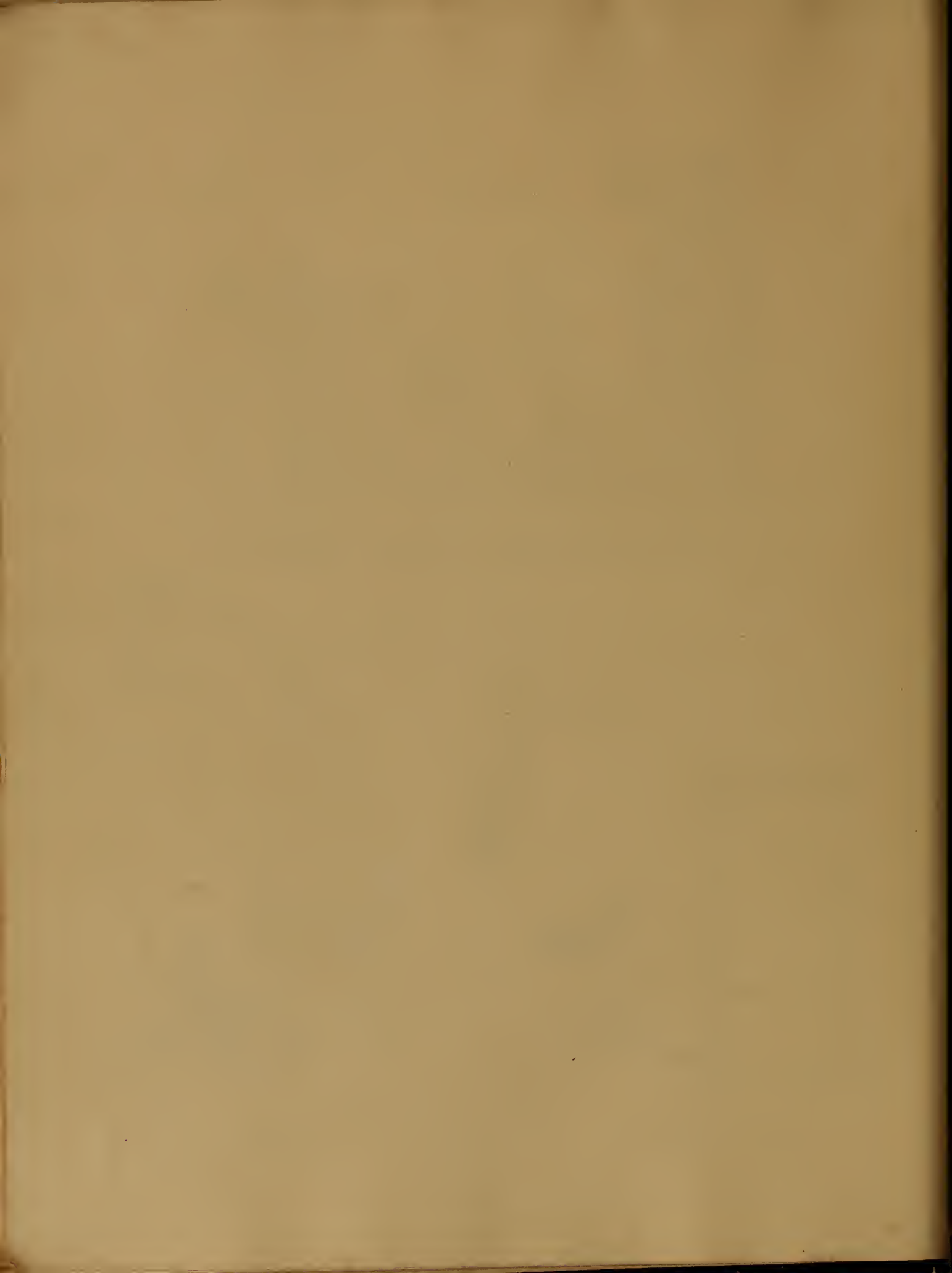


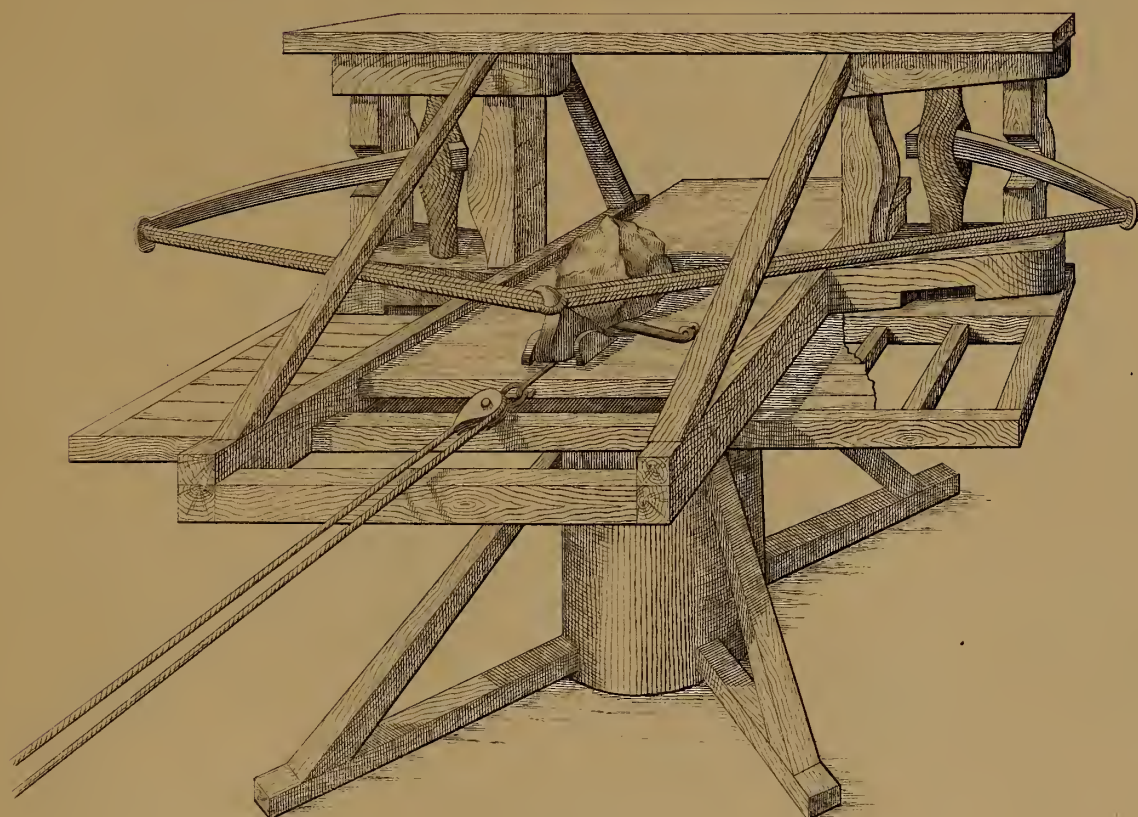
FIG. 3.

Trepied.





Detail of Springs.



Balista.

Henry Vernon, Staff-Sergeant, &c.

Day & Son, Lith^{rs} to the Queen.

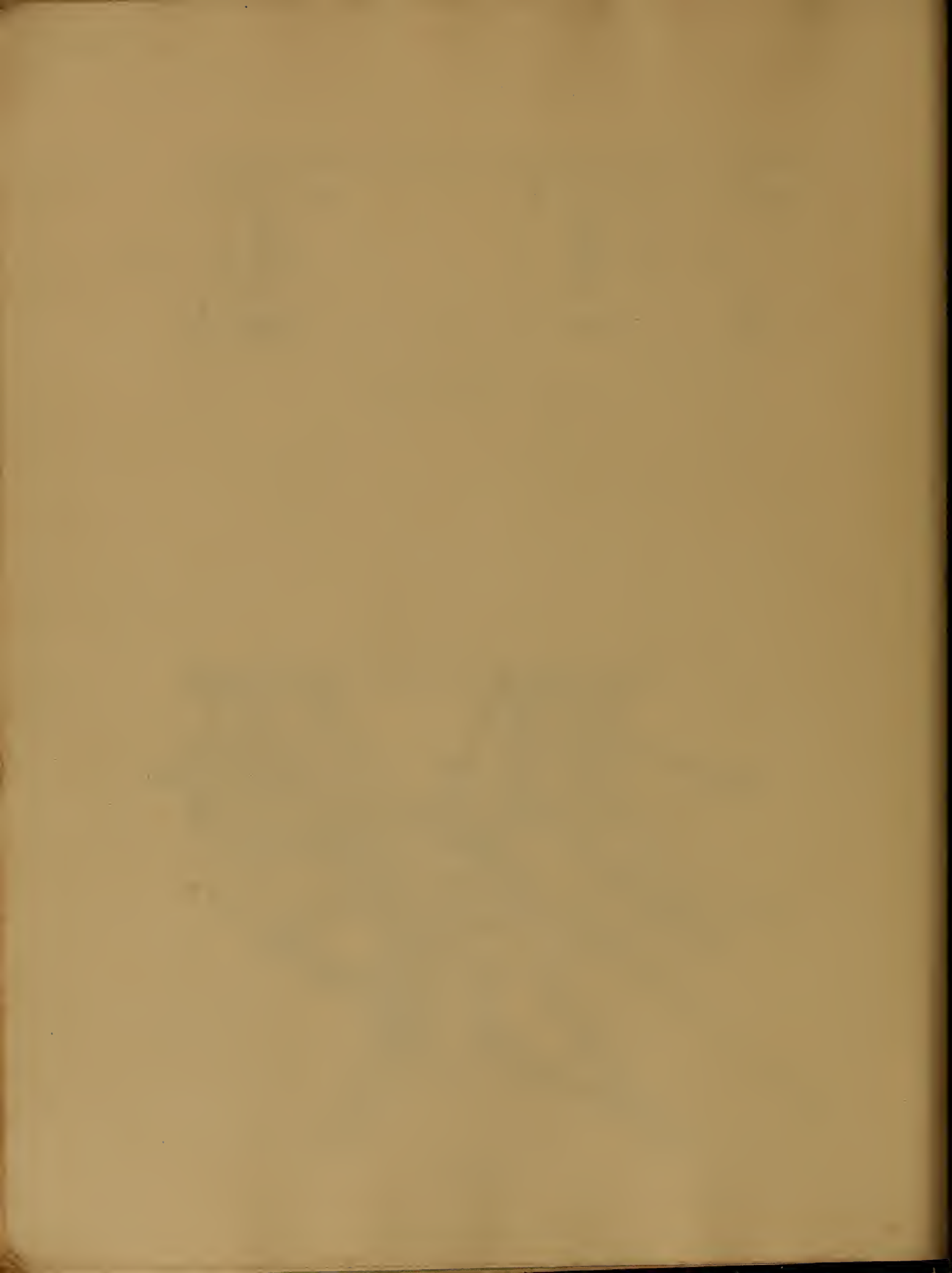


FIG. 3.



FIG. 1.

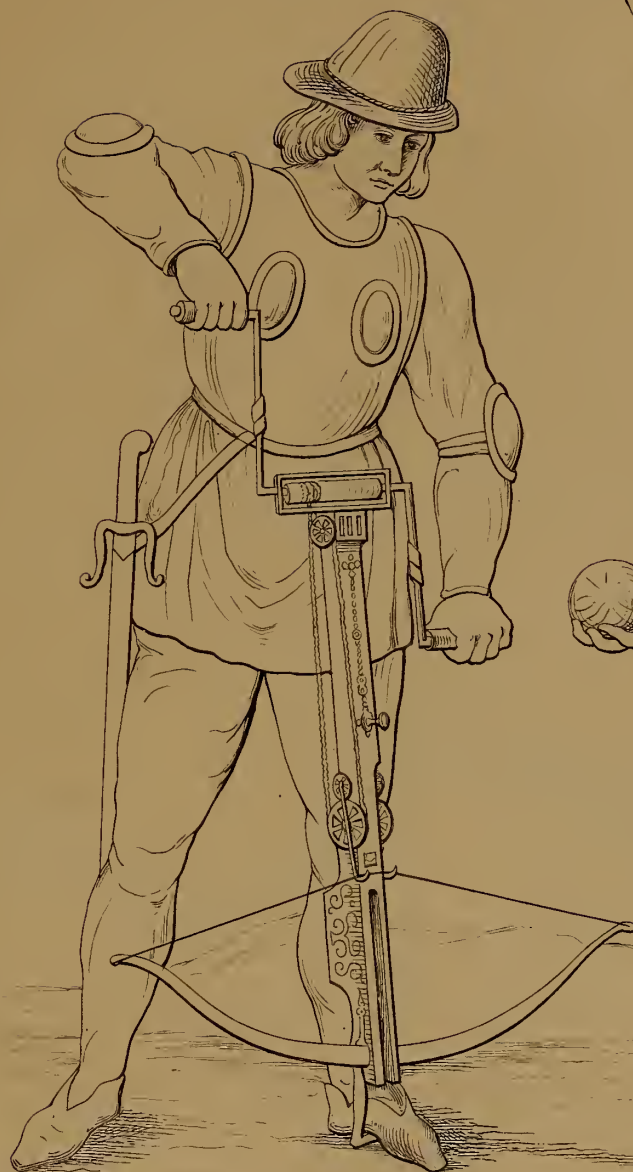


FIG. 2



Harry Vernon. del.

A Cross bow man and Slinger.

Day & Son Lith^{rs} to the Queen.

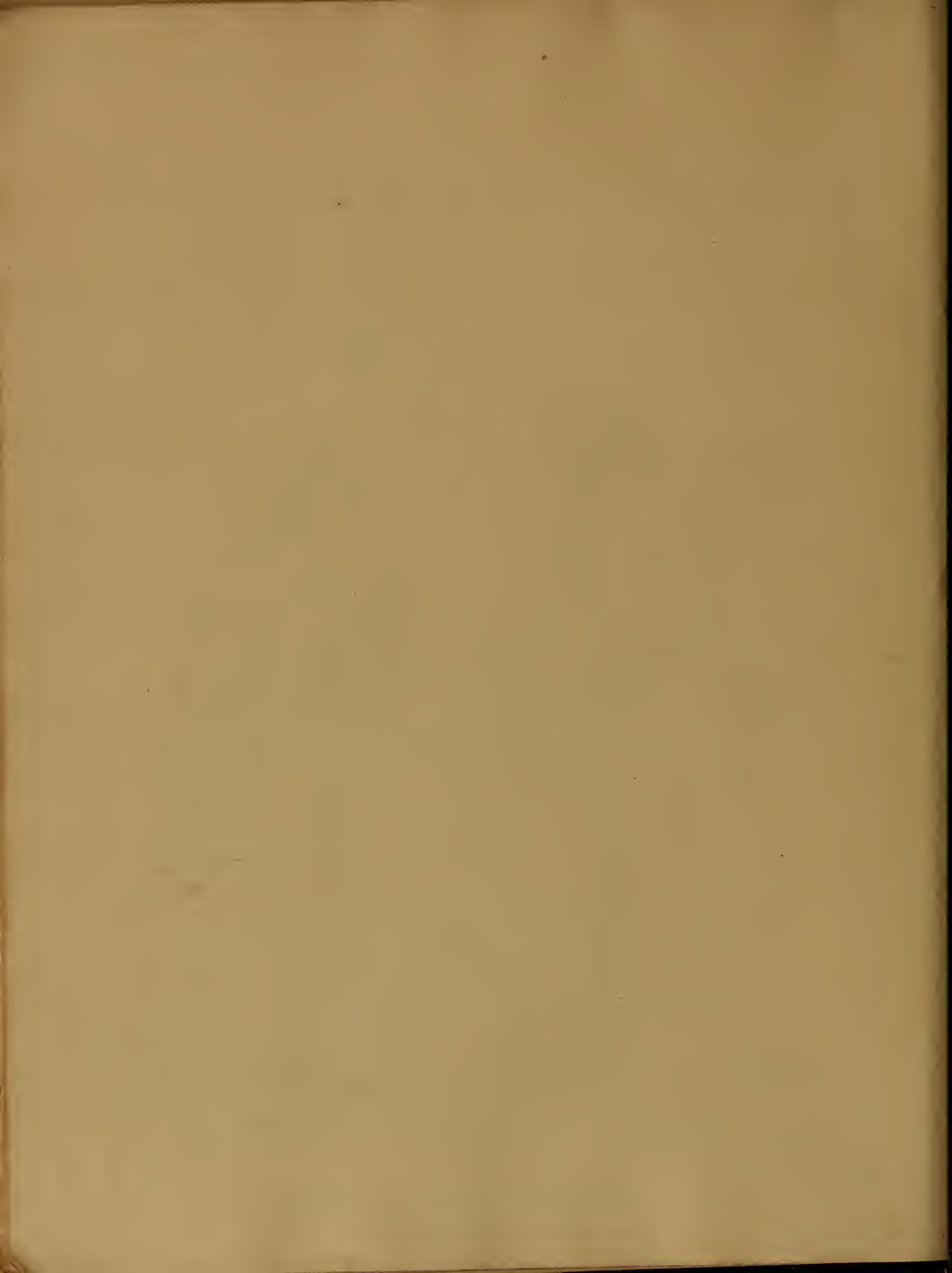


FIG. 1.

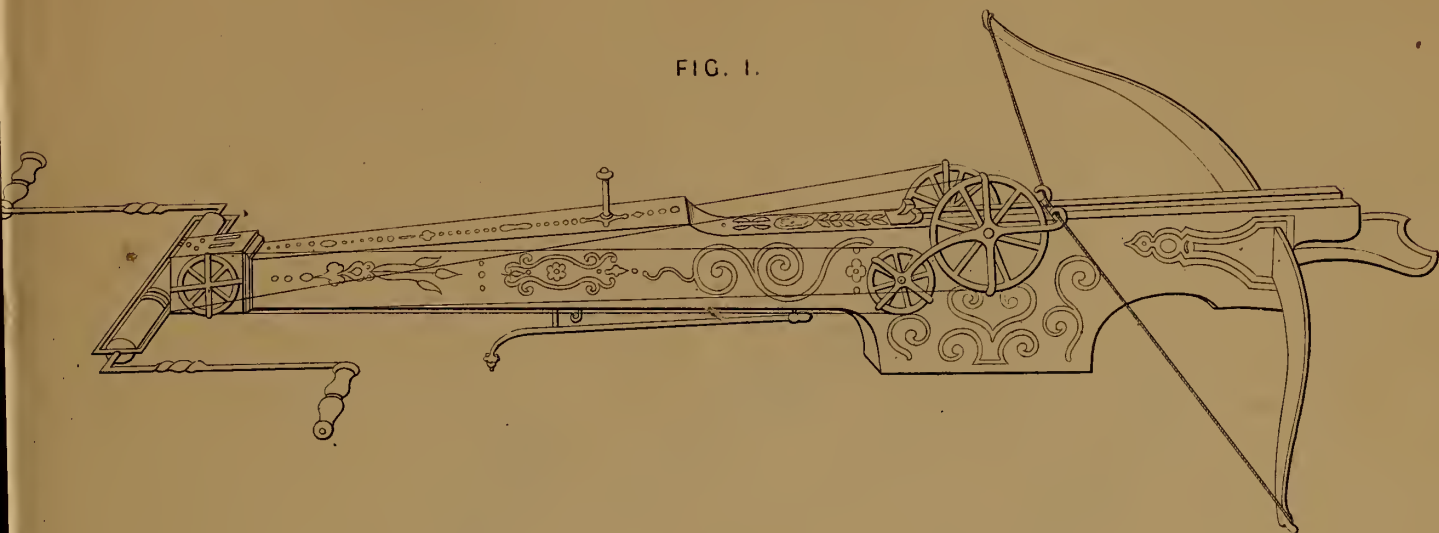


FIG. 2.

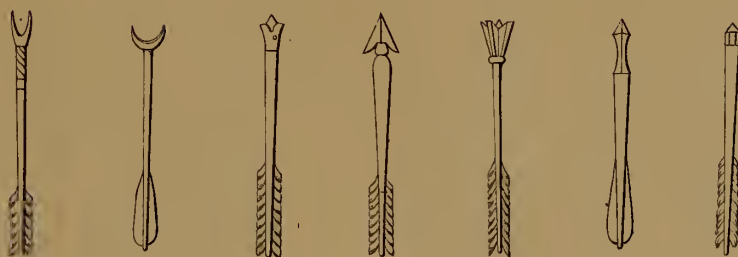


FIG. 3.

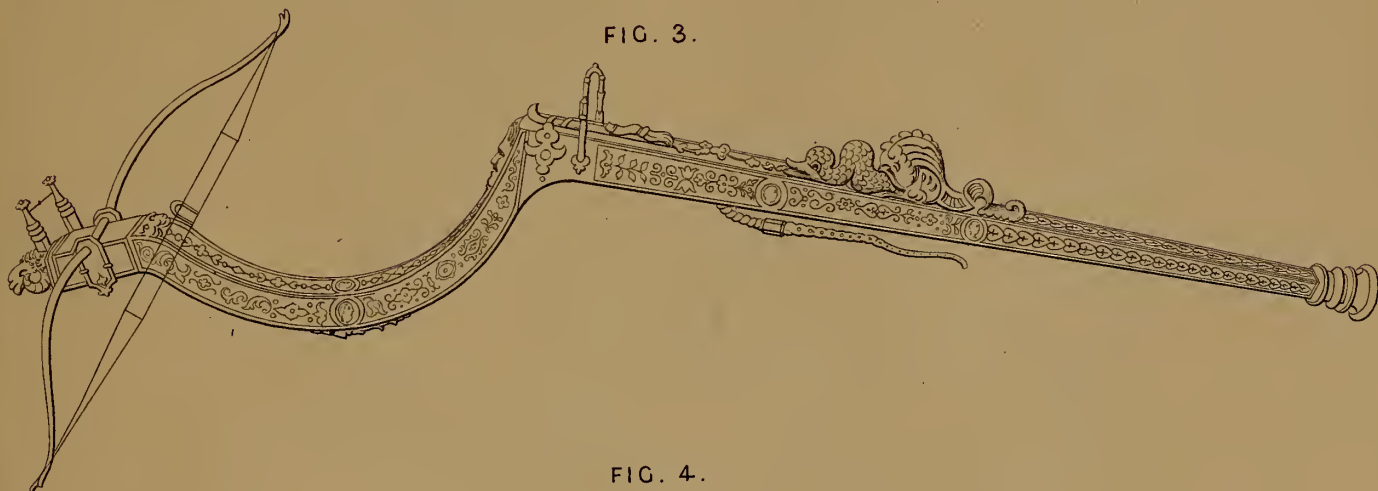
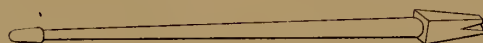
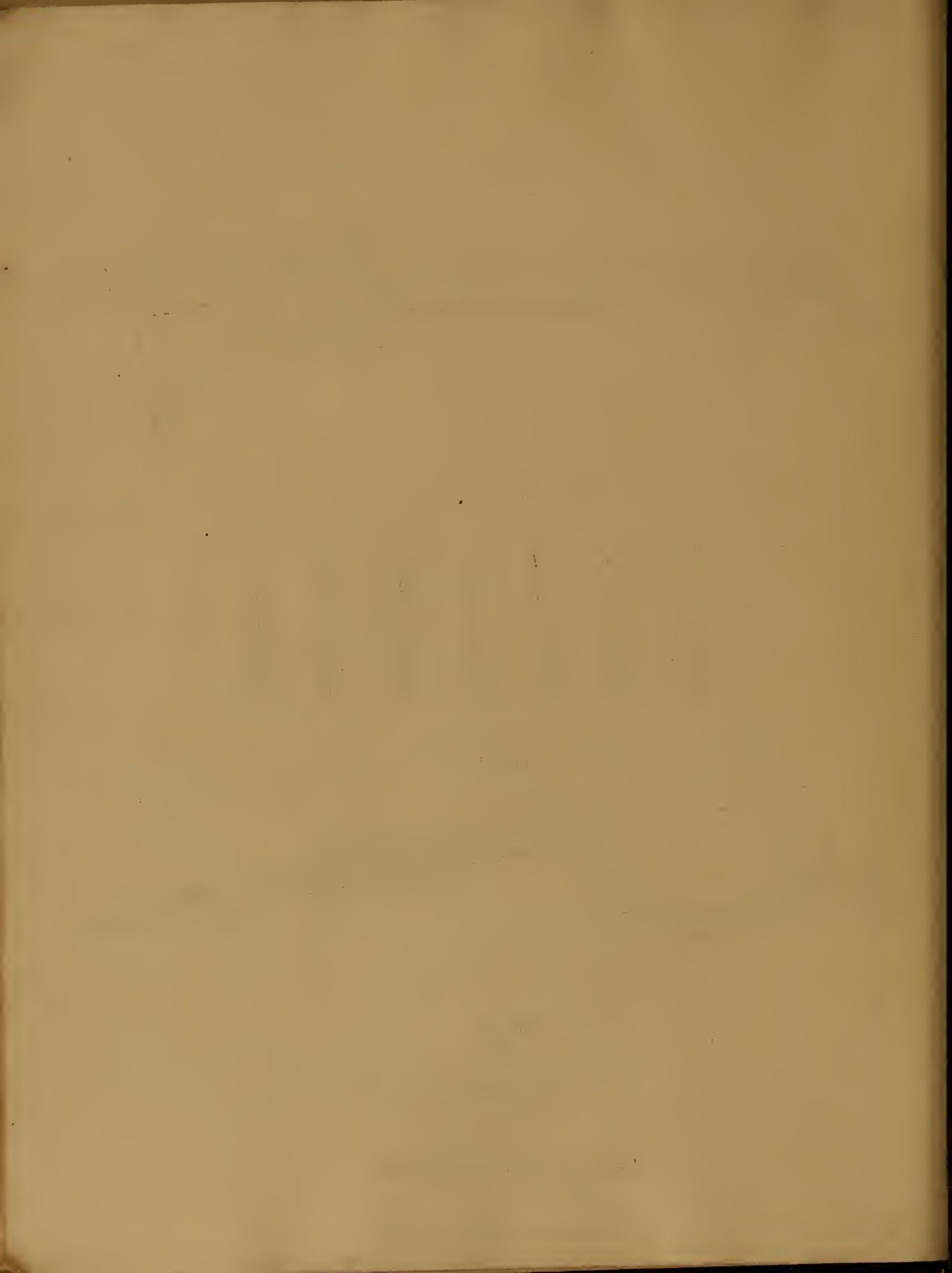
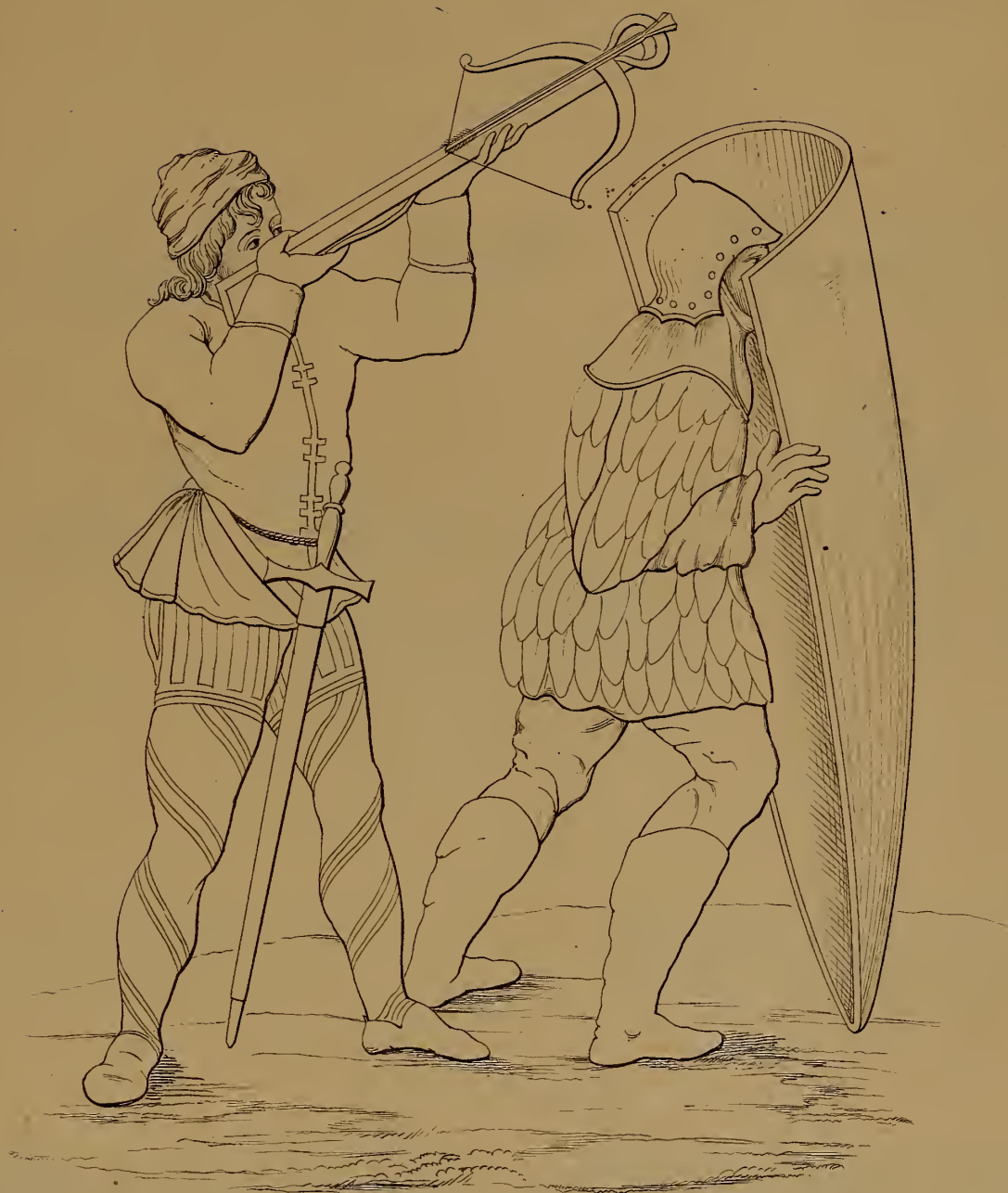


FIG. 4.



Cross-bows and Quarrels.





Harry Vernon del.

A Cross bow man and his Paviser.

Day & Son Lith^{rs} to the Queen.

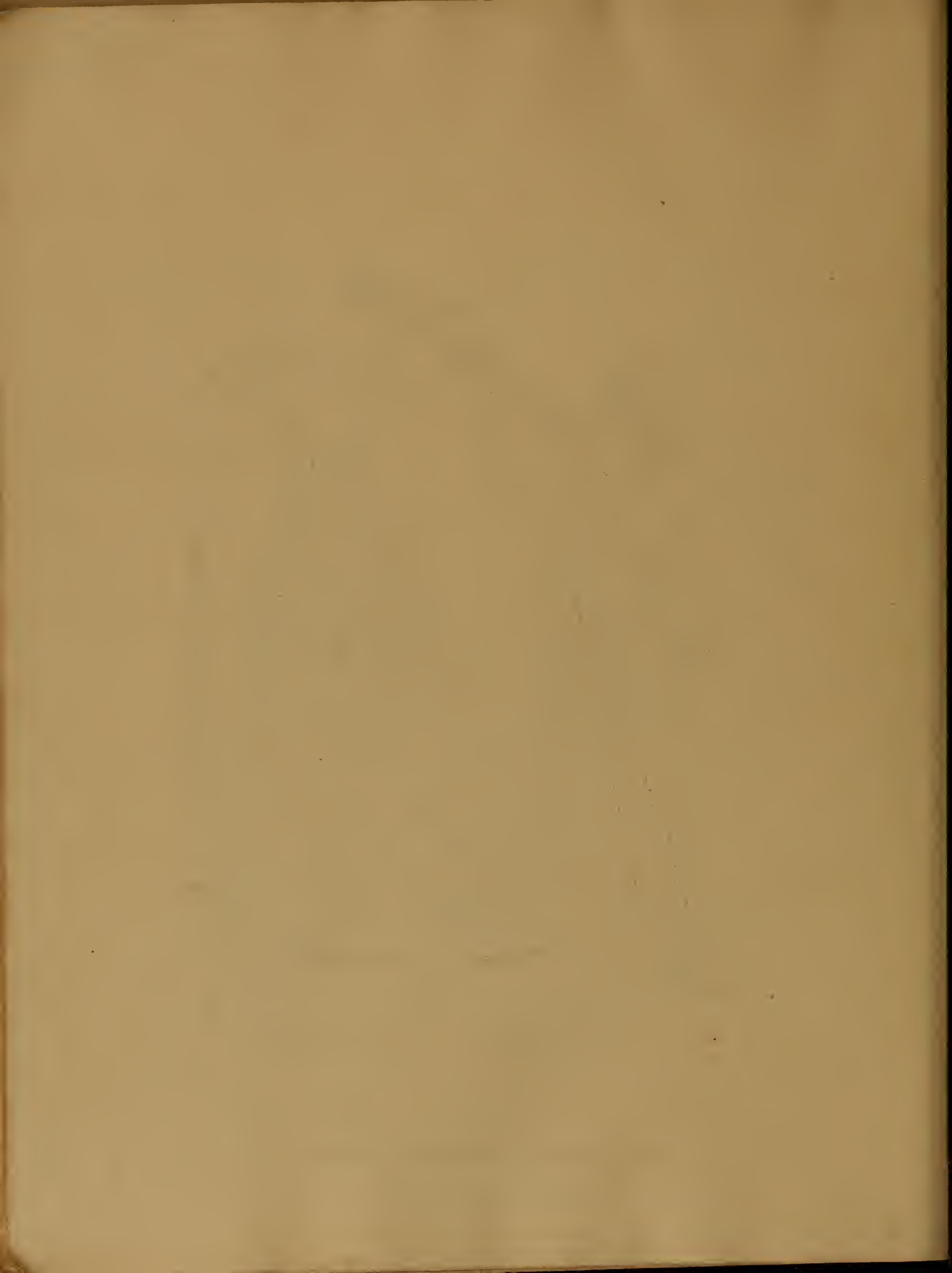
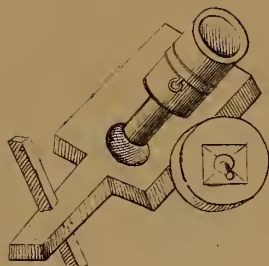


FIG. 1.



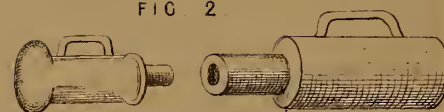
Gun and Querrel Temp.
Edward 3rd Sloane M^{ss}

FIG. 3.



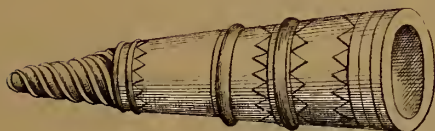
Santini M^{ss} Early part of 15th Century

FIG. 2.



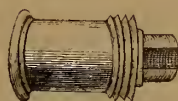
Small chambered Cannon
from the Santini M^{ss}

FIG. 9.



Ancient Screw piece

FIG. 10.



Ancient Screw Breech loader

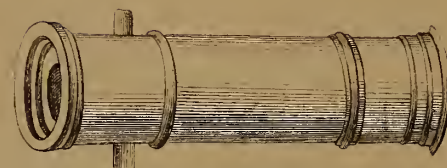
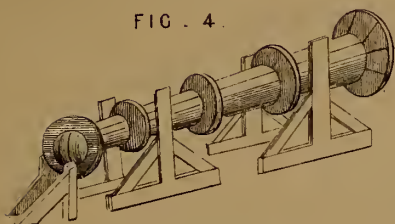
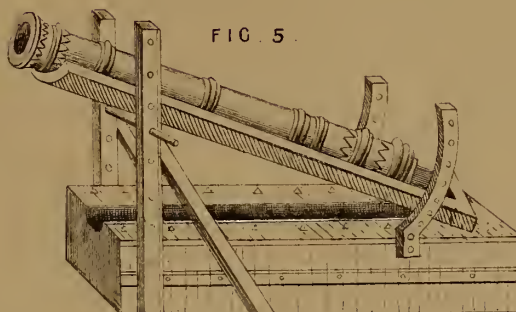


FIG. 4.



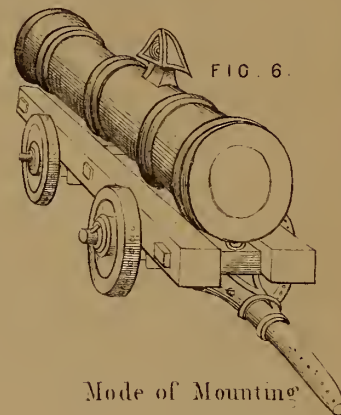
Mode of mounting
from Froissart.

FIG. 5.



Method of obtaining elevation

FIG. 6.



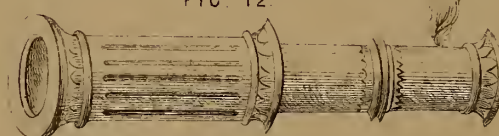
Mode of Mounting
from Valturius

FIG. 11.



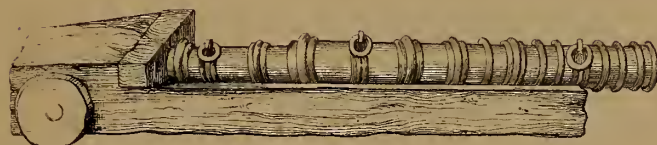
Chinese Field piece Peiho 1860

FIG. 12.



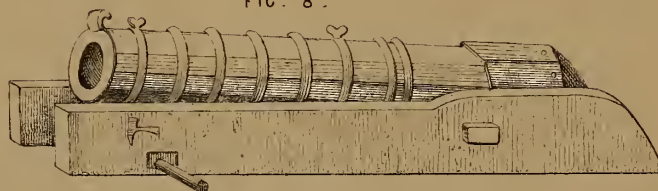
Ancient howitzer Cannon for
throwing balls Filled with powder

FIG. 7.



From the wreck of the "Mary Rose" Temp: Henry 8th

FIG. 8.



Hoopd Cannon in wooden bed

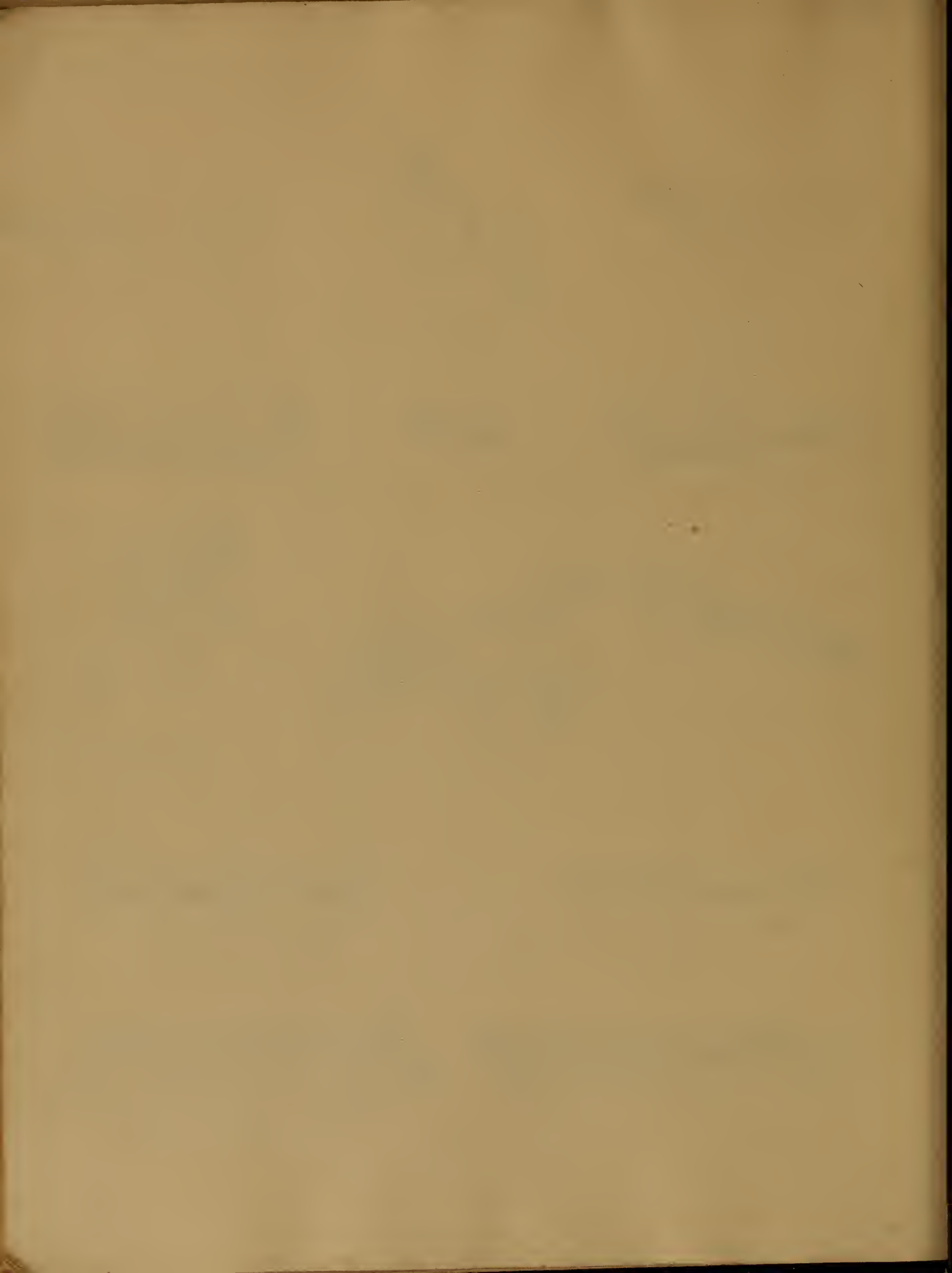


FIG . 1 .

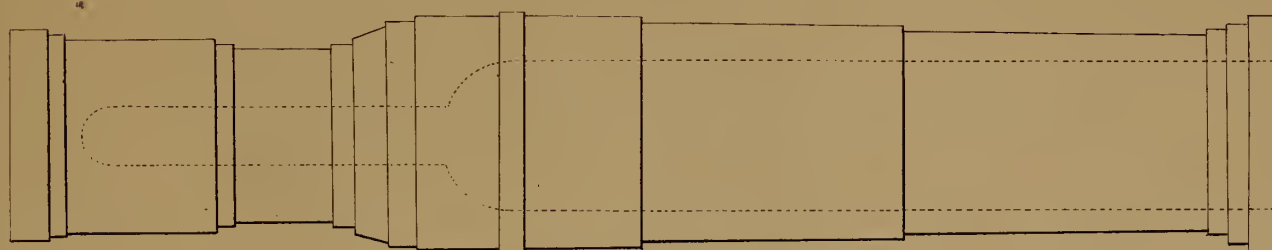


Giorgio Martini , 15th Century, latter part

FIG . 2 .



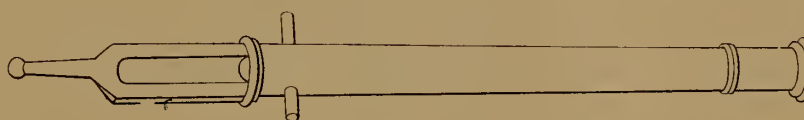
Queen Elizabeth's Pocket Pistol



Mons Meg.



Chamber



Pierrier or Paterera — 16th Century.

H. Cauley del.

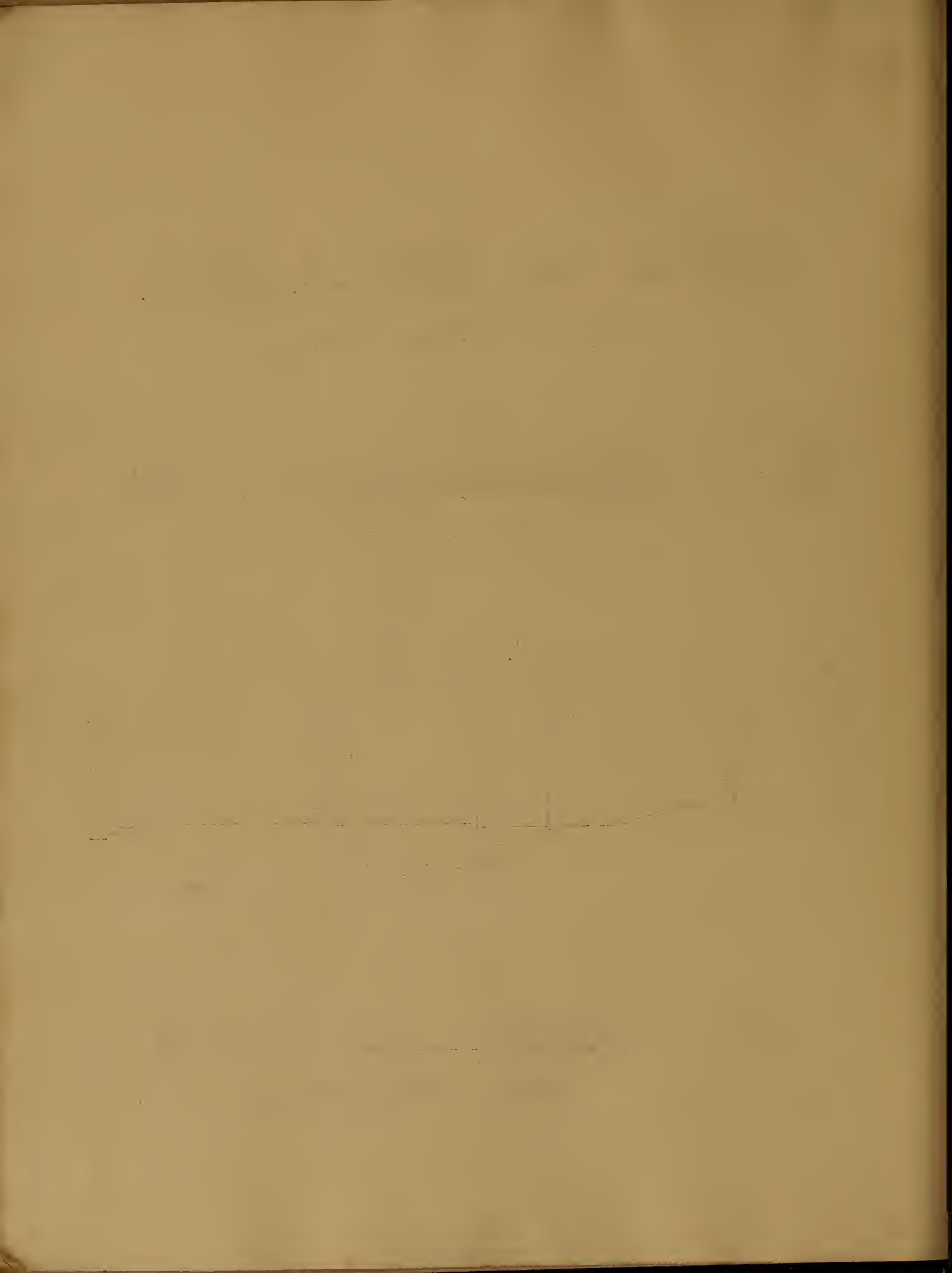
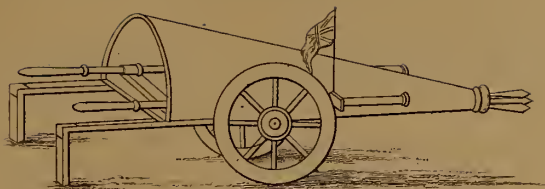
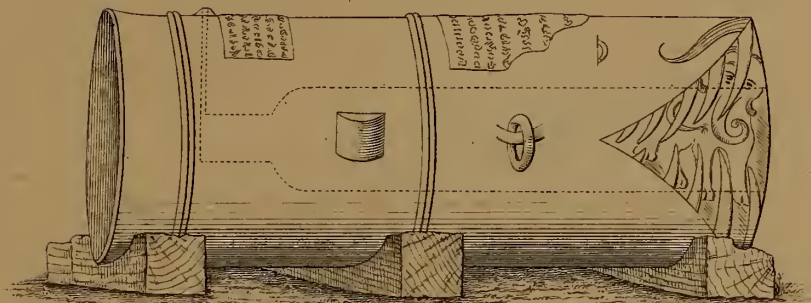


FIG. 1.



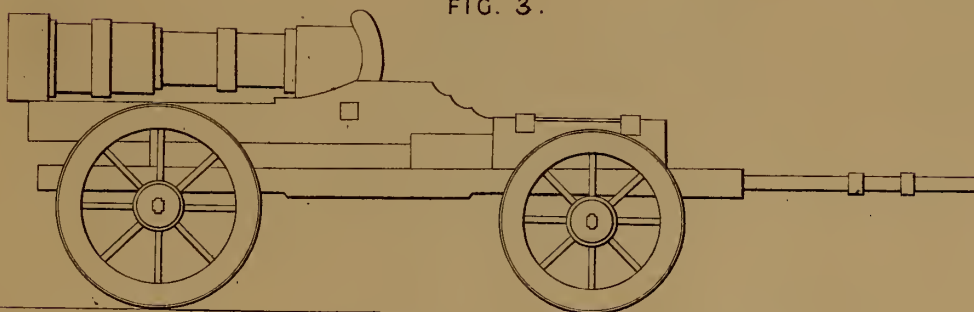
Cart of War.—Temp: Henry 8th.

FIG. 2.



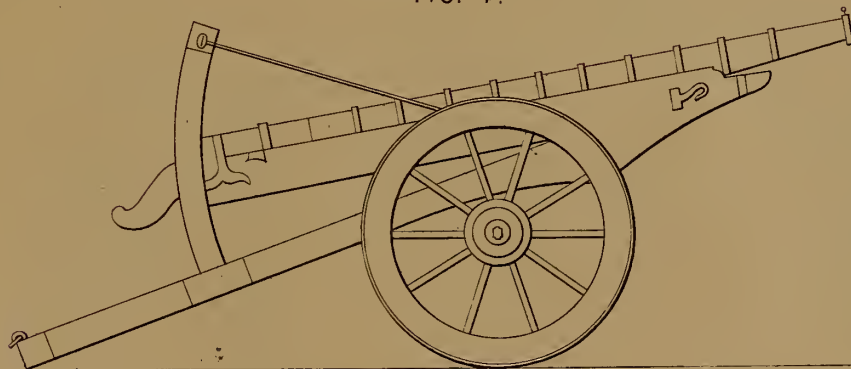
Moolik i Meidan"

FIG. 3.



Bombard and Carriage.—15th Cent^y.

FIG. 4.

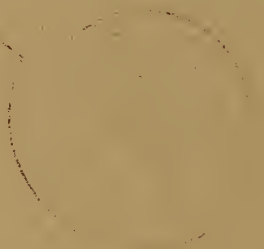


Long Serpentine of Wrought Iron.—15th Cent^y.

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LIBRARY

1900



THE UNIVERSITY OF CHICAGO

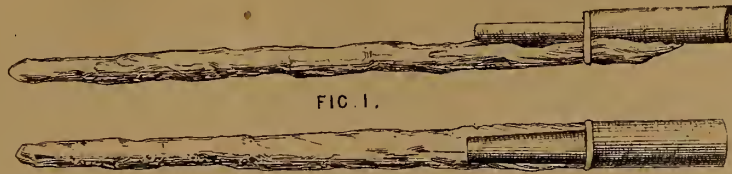


FIG. 1.

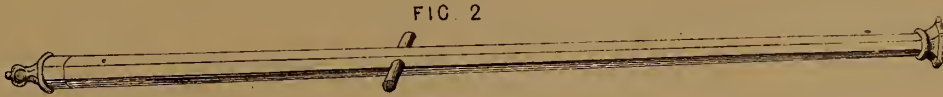


FIG. 2.

FIG. 7.



FIG. 11.



FIG. 12.



FIG. 3.



FIG. 6.



FIG. 4.



FIG. 5.



FIG. 8.



FIG. 9.



Musketeer 16th Cent^y.

FIG. 10.



Earliest form of Hand Gun





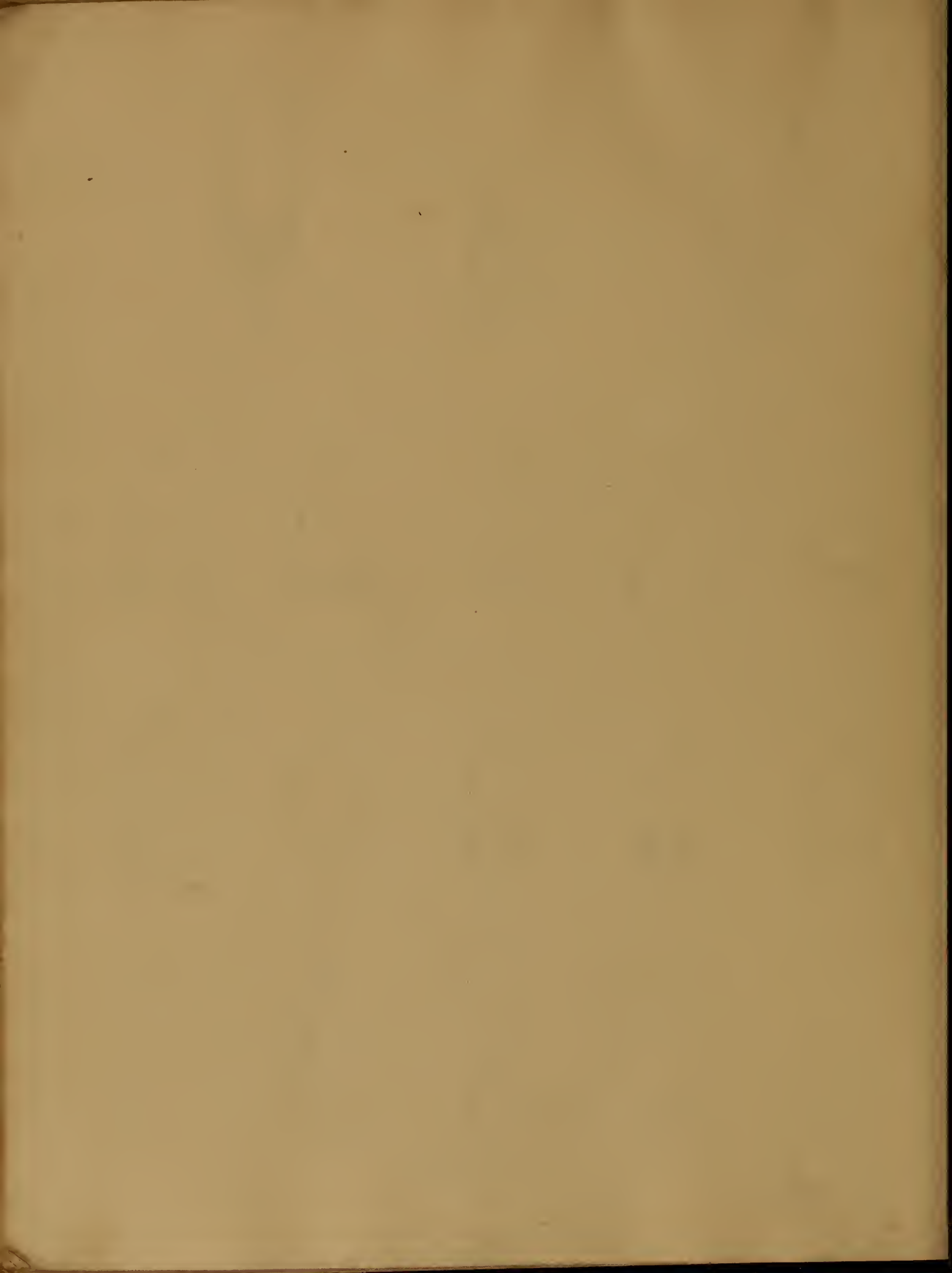


FIG. 1.

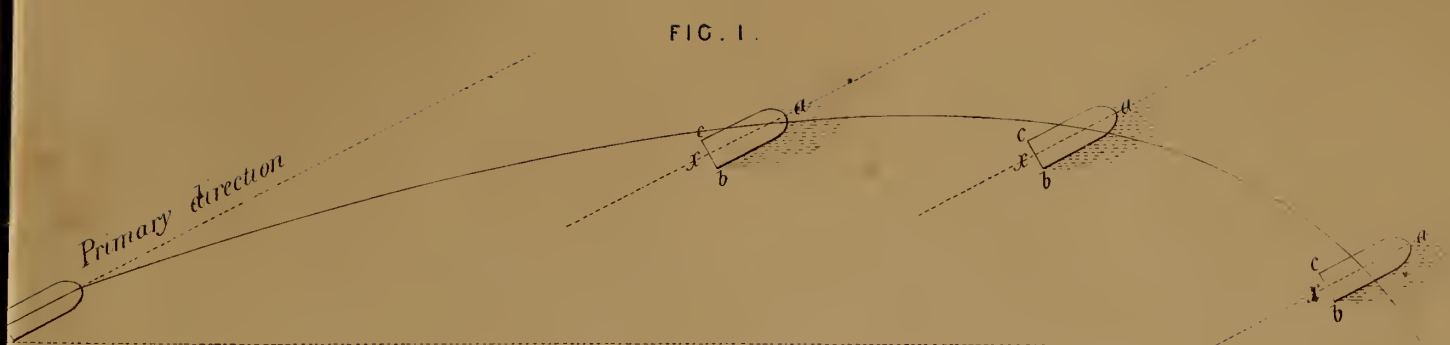


FIG. 2.

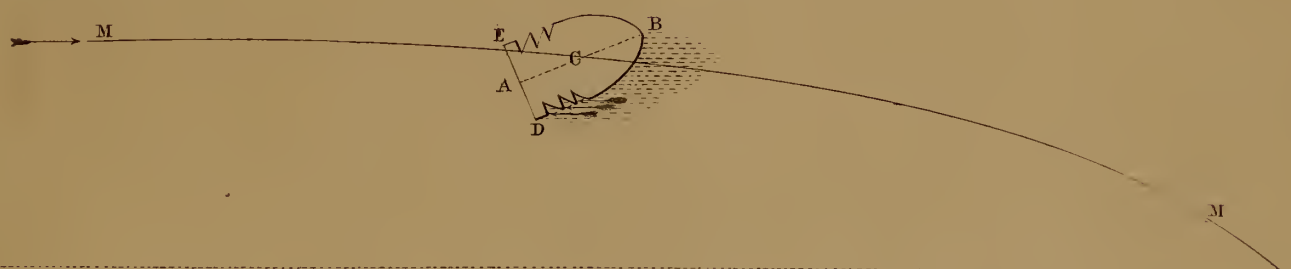


FIG. 3.



FIG. 4.

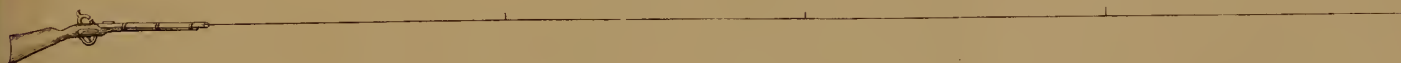
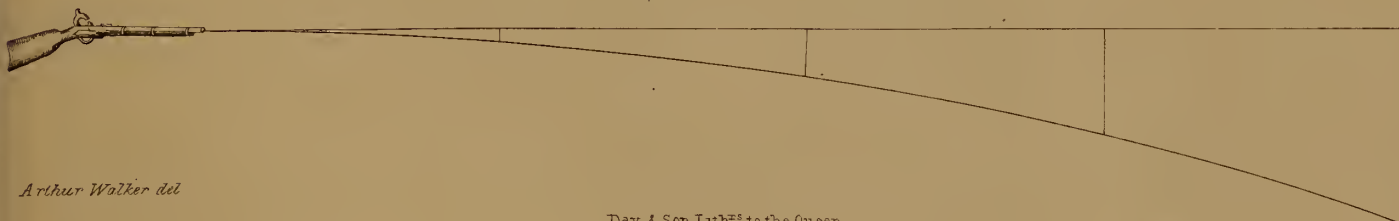


FIG. 5.



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FIG. 1.

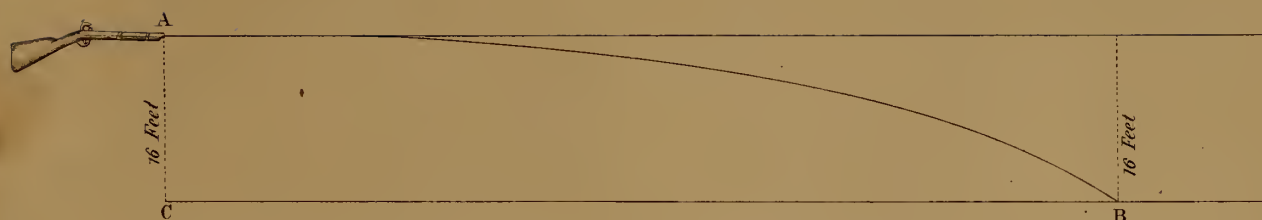


FIG. 2.

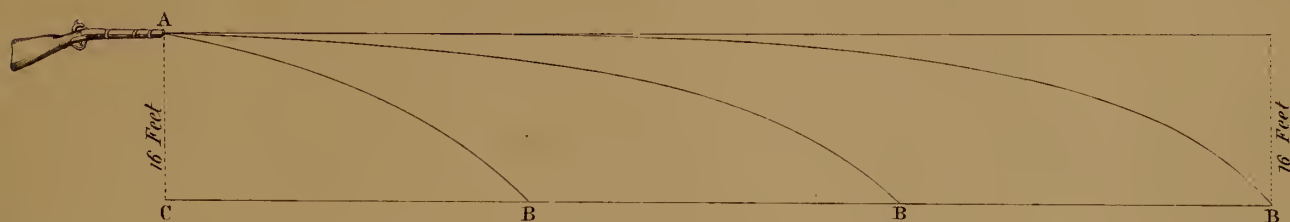


FIG. 3.

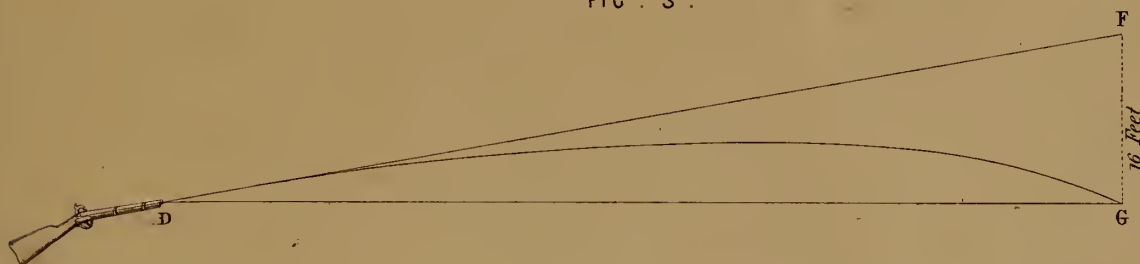
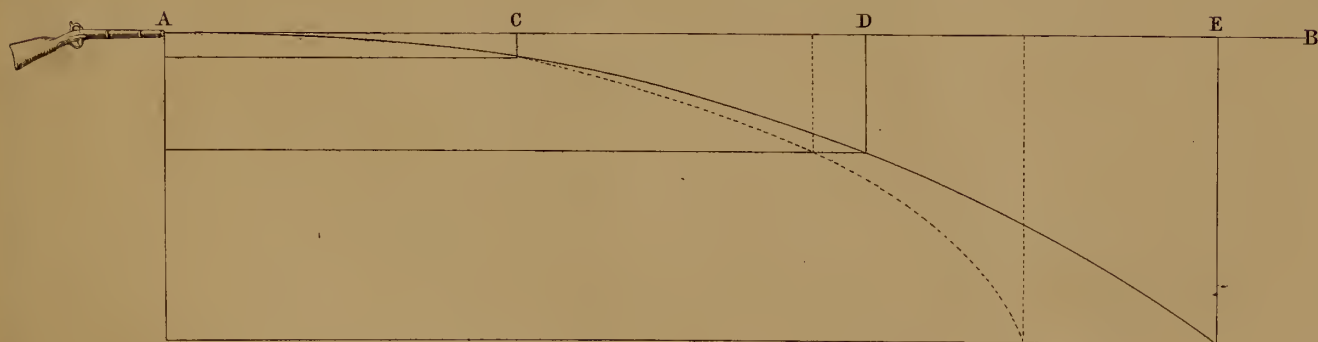


FIG. 4.



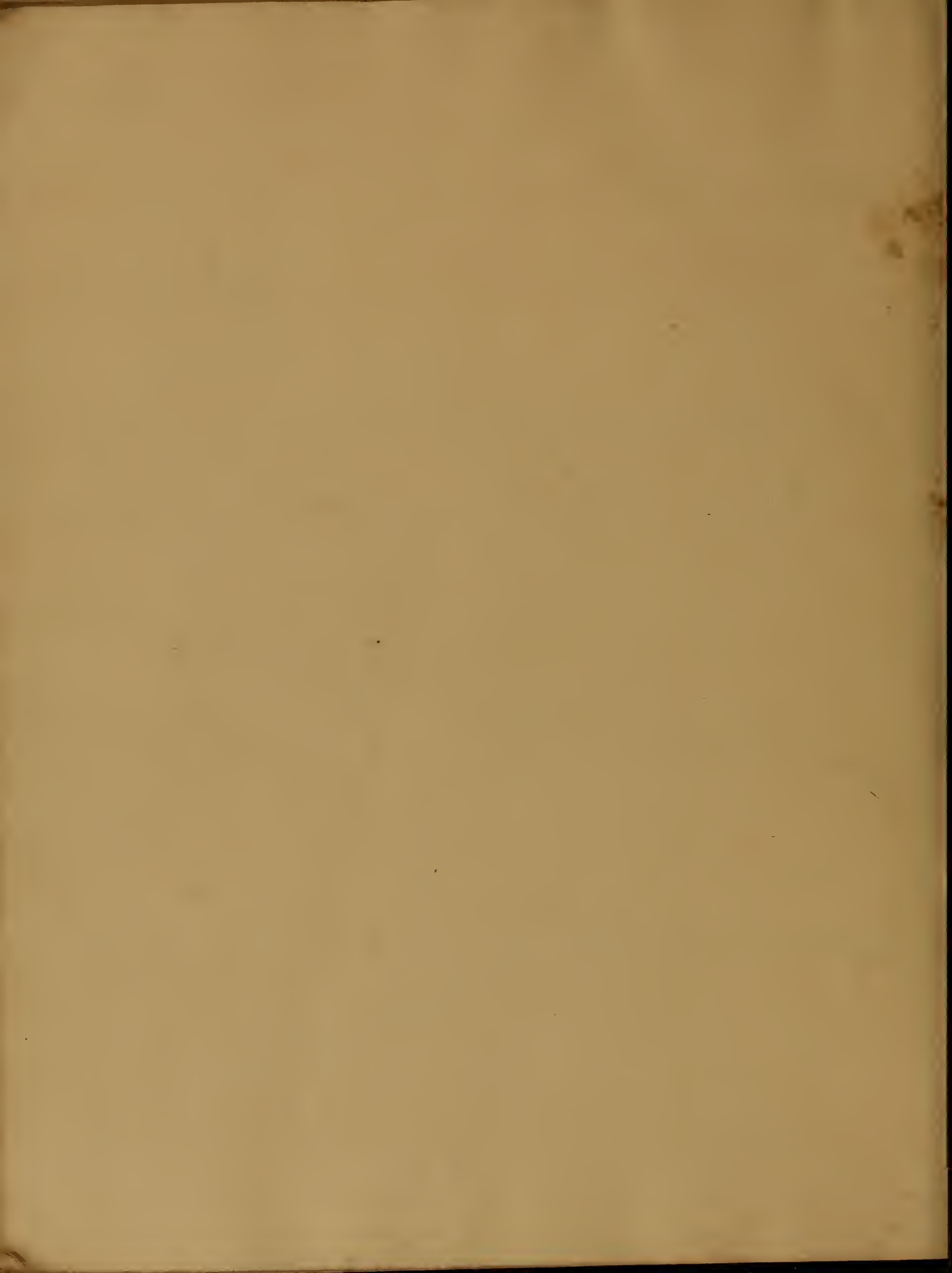


FIG. 1.

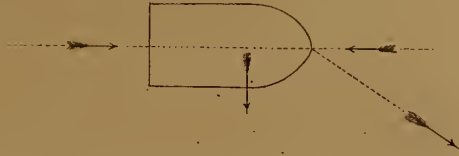


FIG. 2.

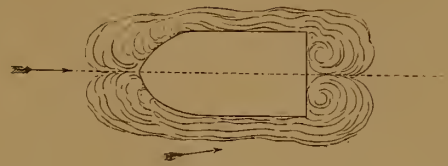


FIG. 3.

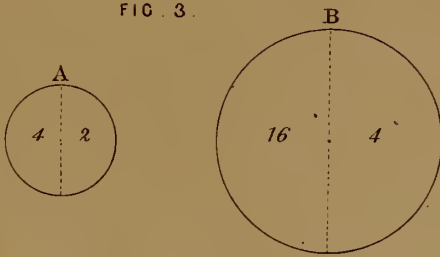


FIG. 4.

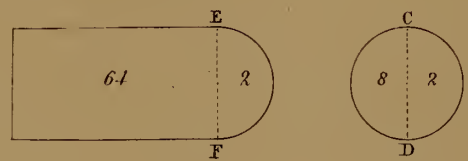


FIG. 5.

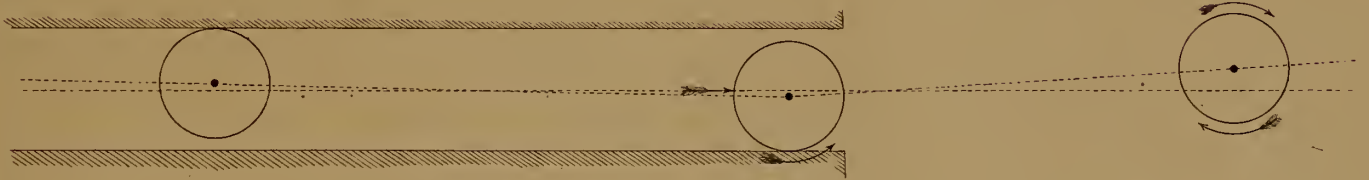
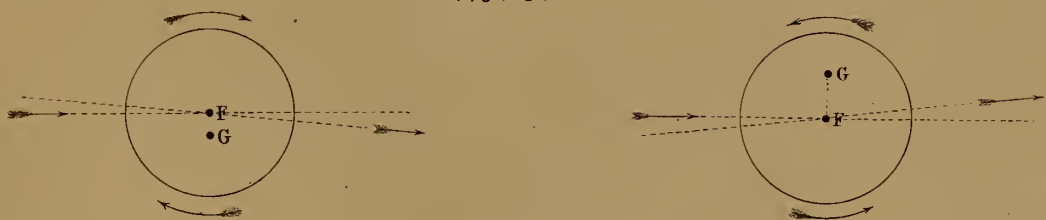
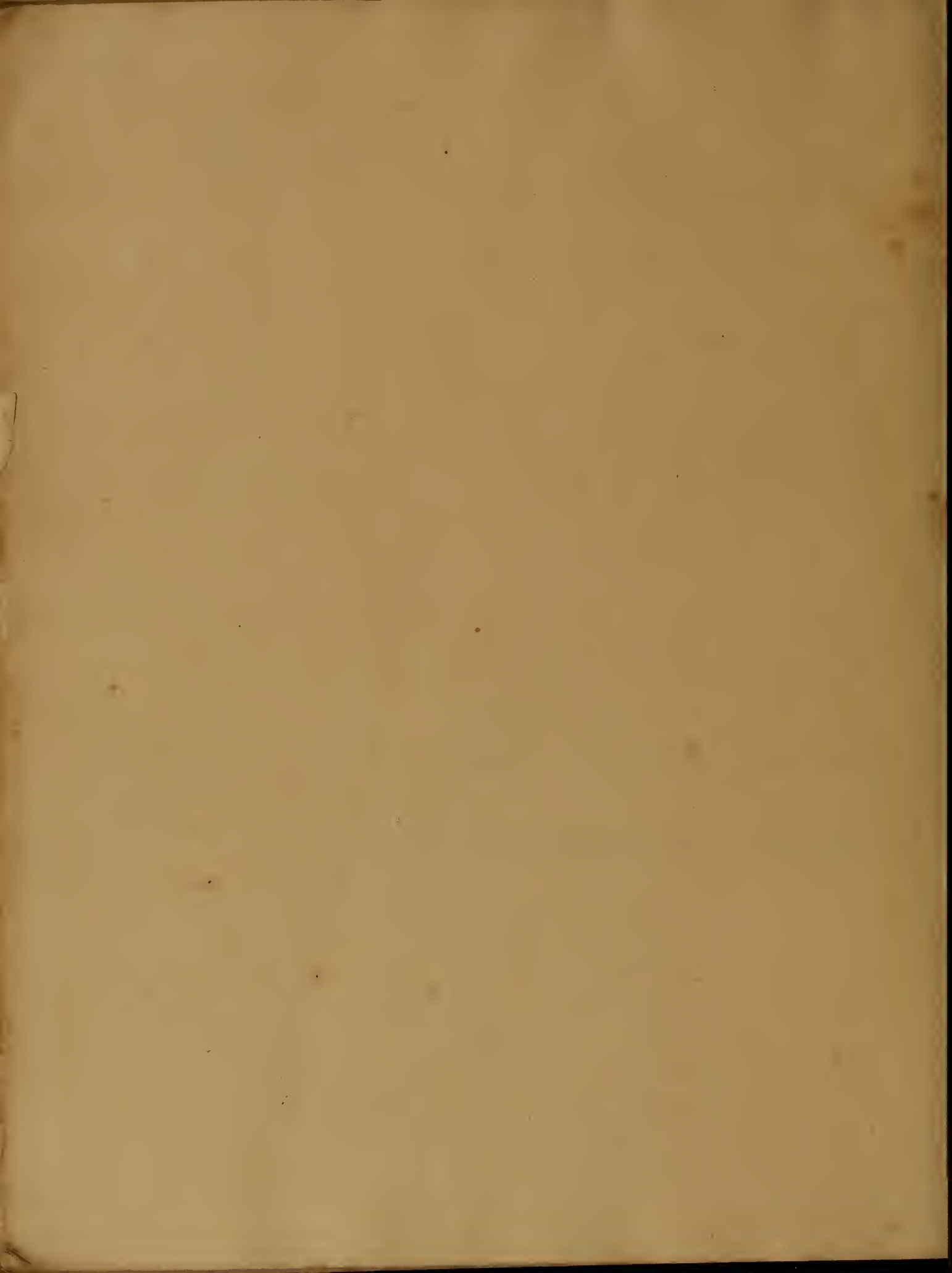


FIG. 6.

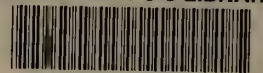




259

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